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Discussion of all papers is invited

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CLEANING WATER MAINS, RESULTS AND COSTS[1]

By Thomas J. Skinker[2]

The present water supply for the city of St. Louis is obtained from the Mississippi River at the Chain of Rocks, about 10 miles north of the center of the City.

Prior to 1904 the river water entered our plant through an intake, 1500 feet east of the west bank of the river which was connected to a wet well by a 7-foot circular, brick lined tunnel, 2197 feet long.

The water entering the tunnel, flowed by gravity to the wet well whence it was pumped against a dynamic head of 58.3 feet into the delivery well, flowing from there into the settling basins. There were six of these basins, 400 feet long by 600 feet wide, with a total capacity of 30,000,000 gallons each.

The method of operation was to fill these basins, let the water stand in them as long as possible and draw it off, first from the first basin filled, then from the next in order, etc. From these basins the water flowed by gravity through an 11-foot brick conduit to the Baden Pumping Station, 3 miles south of the Chain of Rocks, and from there through a brick conduit, 9 feet in diameter to Bissell's Point Pumping Station, located 7 miles south of the Chain of Rocks.

The deposit in the mains up to 1904 was mostly mud with some tuberculation. In 1904 the treatment of the raw water with lime

[1] Presented before the Indiana Section meeting, February 24, 1929.
[2] Engineer in charge of distribution, Water Department, St. Louis, Mo.

and iron was begun, and in 1915 the filter plant was put in operation. Between 1904 and 1915 there was a heavy calcium carbonate deposit in the mains.

I remember very distinctly in 1898, when I first came to St. Louis from the country, I had a hard time getting accustomed to drinking the water because it was so muddy. The earliest records that I can find showing the condition of raw and tap water were of analyses made in 1906. At that time the river water had a maximum of 2483 p.p.m. suspended solids, a minimum of 195, and an average of 1209; the tap water had a maximum of 200, a minimum of 69, and an average of 120.

The accumulation of mud, calcium carbonate and tuberculation in the mains had in some cases reduced the efficiency of the main to as low as 23.5 per cent of new pipe.

The machine originally used in cleaning the smaller size mains consisted of two or more sections, flexibly connected, each having a number of steel saw-tooth and plain end scraping blades, securely fastened to a common center.

On the larger sizes of pipe a pontoon type machine was used. There was a central air chamber which served as a rigid axis for the cutting blades and gave the machine enough buoyancy when in the water to prevent the over-cleaning of the bottom of the pipe to the detriment of the top. Two different machines had been used in St. Louis. The first one had five heads, each containing 80 blades. The first and last sections were welded to the pontoon while the middle three were hung in place by chains, the theory being that the machine would go around curves more readily than if all heads were attached rigidly to the air chamber. These loose heads proved to be detrimental in one case. This old type machine is shown in figure 1.

Preparations were made to clean 18,446 feet of 36-inch main in one shot. This main had been in service for fifty years. The machine was inserted and the water turned on. The machine was progressing at a speed of about 85 feet per minute and had traveled more than half-way when passing a 36 by 36 three way the machine swerved off line sufficiently to jam. After working several days, the dome of a nearby valve was removed and the main entered. The machine was pulled past the three way and the shot completed without further trouble. This machine was scrapped and a new machine designed.

The new machine had six heads of 80 blades each. The first three were saw-tooth and the rear three scrapers, all rigidly attached to

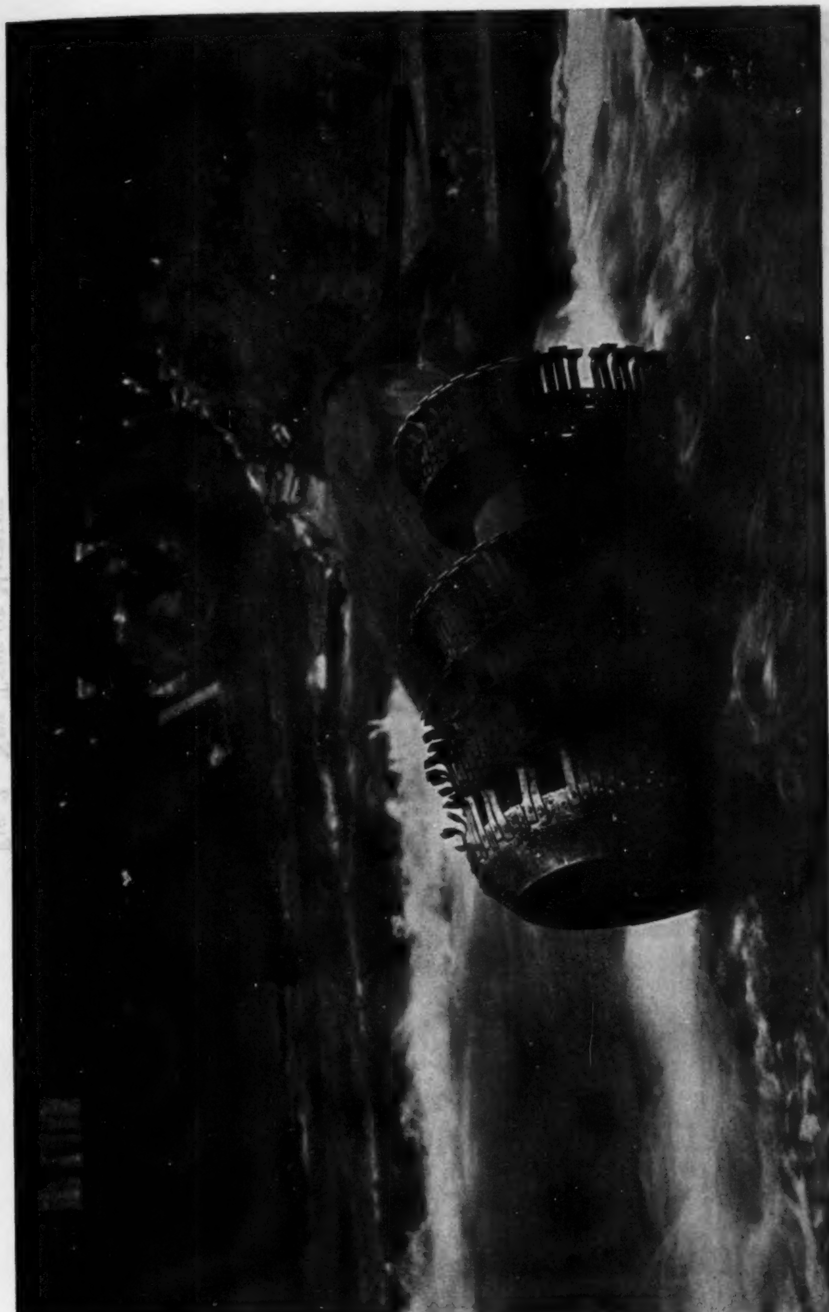

FIG. 1. OLD TYPE MACHINE FOR CLEANING MAINS

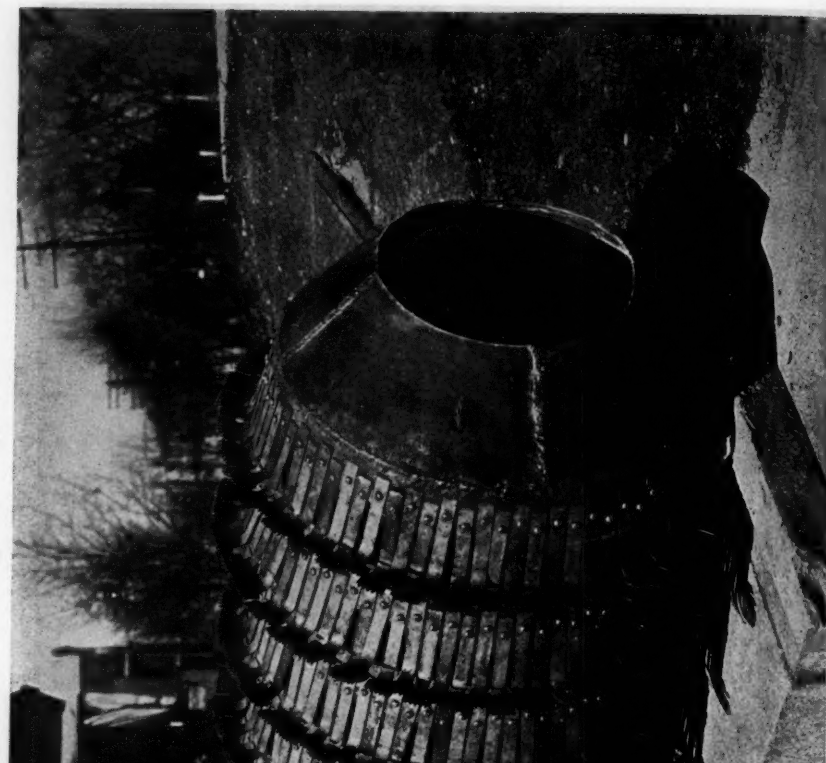

FIG. 2. NEW TYPE OF MACHINE

TABLE 1

Cost of pipe cleaning, 1908 to 1928

YEAR	6 INCH	COST PER FOOT	8 INCH	COST PER FOOT	10 INCH	COST PER FOOT	12 INCH	COST PER FOOT	15 INCH	COST PER FOOT	20 INCH	COST PER FOOT	30 INCH	COST PER FOOT	36 INCH	COST PER FOOT	TOTAL NUMBER OF FEET	COST
	feet	*cents*	*feet*	*cents*	*feet*	*cents*	*feet*	*cents*	*feet*	*cents*	*feet*	*cents*	*feet*	*cents*	*feet*	*cents*		*dollars*
1908*	1,200				1,150												2,350	569.08
1912									4,904	24	18,542	29					23,446	5,517.09
1913§	4,459	16							11,639	20	3,267	27½					19,365	3,946.54
1917–18	57,296	17	15,691	17	1,180	17	115,025	17	7,205	19	70,125	19					266,522	47,015.42
1918–19	212,822	19	10,036	19	20,975	19	144,446	19	12,320	19	86,414	19					487,013	92,967.81
1920–21							91,616	28			79,353	28	16,615	36	45,964	36	233,548	70,353.29
1928†	5,313	10	4,752	10													10,065	1,065.50
	281,090		30,479		23,305		351,087		36,068		257,701		16,615		45,964		1,042,309‡	221,434.73

* No bid price. Paid on force account, plus.

† Contractor furnished superintendent and machines only.

‡ 197.4 miles.

§ Two cents additional per foot for work done between 6:00 p.m. and 6:00 a. m.

the central air chamber. The diameter of the heads from tip to tip was 38 inches. The volume of the air chamber was made smaller to prevent over cleaning the top of the pipe which occurred with the old machine. A metal disc with adjustable openings mounted in an expanding steel cage was provided to drive the machine and allow some water to pass by to wash out the loosened material. The machine is shown in figure 2.

The method of cleaning is as follows: A section to be cleaned is valved off and a piece of the pipe about 3 feet long is cut out of each end. The pipe between the valve and the opening at each end is then hand scraped. At the far end is placed a 45 degree curve and piece of pipe extending up to the street surface. At the near end a cone-

TABLE 2

Costs on pipe cleaning work in the downtown section

LOCATION	SIZE OF MAIN	DISTANCE	COST PER FOOT	
			With material	Without material
	inches	*feet*	*cents*	*cents*
Olive—7th to 12th	6	1,375	32	30
Clark—7th to Broadway	6	675	25	21
St. Charles—7th to 12th	6	1,856	34	$31\frac{3}{4}$
Morgan—4th to 7th	6	945	39	36
9th—Washington to Locust	6	462	42	37
6th—Cass to Pine	8	4,752	24	$22\frac{1}{3}$
Average per foot			$32\frac{2}{3}$	$29\frac{2}{3}$

shaped float attached to a $\frac{1}{8}$-inch cable is placed in the main. This cable is fed from a reel through a special sleeve which is fitted and fastened in the place where the piece of pipe was cut out.

Then water is turned on and the cable shot through. The sleeve is removed and a large cable is attached to the small one and pulled through. The machine is then attached to the large cable and placed in the pipe. The pipe is then sleeved up, the water turned on, and the machine pulled through.

Where the pontoon type of machine is used the breakouts are made the same as mentioned before, the machine is inserted, the pipe sleeved up and the water turned on. Pipe as small as 10 inches may be cleaned with the pontoon type machine if the pressure is sufficient to drive it.

The number of feet of main cleaned each year and the cost of cleaning per foot for the various sizes of pipe are shown in table 1.

In 1908 the work was done on a cost plus basis. In the work done from 1912 to 1921 inclusive the National Water Main Cleaning Company furnished all labor. The Water Division provided a foreman to supervise valve operations, keep records, furnish pipe, sleeves, lead, etc.

In 1913 some of the work had to be done at night and for this work we paid an additional 2 cents per foot.

TABLE 3

Summary of data on cleaning of water mains in 1928

LOCATION	SIZE OF MAIN	AGE	DISTANCE	VALUE OF "C"		EFFICIENCY OF PIPE		DIAMETER OF PIPE	
				Before cleaning	After cleaning	Before cleaning	After cleaning	Before cleaning	After cleaning
	inches	*years*	*feet*			*per cent*	*per cent*	*inches*	*inches*
Clark—3rd to Broadway	6	48	675	28	93	23.5	77.5	$4\frac{1}{2}$	6
Morgan—4th to 7th	6	59	945	32	85.5	26.7	71.0	$5\frac{1}{2}$	$5\frac{3}{4}$
St. Charles—7th to 12th	6	47	1,856	35	87.5	29.2	73.0	$5\frac{9}{16}$	6
9th—Washington to Locust	6	49	462	32	81.0	26.7	67.5	5	$5\frac{3}{4}$
6th—Cass to Pine	8	44	4,752	44	85.4	36.6	71.0	$7\frac{11}{16}$	8
Olive—7th to 12th	6	45	1,375	48	84.0	40.0	70.0	$5\frac{1}{4}$	6

Note. "C" is coefficient of roughness as in Williams and Hazen formula. A "C" = 120 was used as a comparison in obtaining the efficiency of pipe. An efficiency of 79 per cent is guaranteed for coated pipe. The above mains were uncoated pipe with the exception of 6th Street.

In 1928 the Water Division furnished all labor and a foremen and all work was done at night in the downtown section. The contractor furnished the cleaning equipment and a superintendent. The total cost was $32\frac{2}{3}$ cents per foot, including the making of excavations and doing all work of cleaning the pipe, permanently repairing the street and hauling way the dirt or flushing off the street. The contractor was paid 10 cents per foot. The Water Division labor amounted to $19\frac{2}{3}$ cents and material cost 3 cents per foot. This is the only job on which I have been able to get the detailed costs. They are shown in table 2.

In the spring of 1928 the National Board of Fire Underwriters

made a study of the distribution system and found that in certain locations the fire flows did not meet their requirements. They recommended that larger mains be laid. To carry out their recommendation would mean tearing up some newly made streets. Upon investigation it was found that the efficiency of the mains in the weak sections was as low as 23.5 per cent of new pipe. Consequently a contract was let for cleaning 10,064 feet of these mains with results shown in table 3.

The determination of the coefficient in Williams and Hazens formula was made before and after each section of main was cleaned. The method used was as follows:

Three fire hydrants were chosen in a block or two of where the cleaning was to take place.

To determine the friction loss in the main, two hydrants, say 300 to 600 feet apart, are chosen and a garden hose attached to each hydrant. At the loose ends of this garden hose, which would be located near the center point between the two plugs, a U-tube is attached that contains carbon tetrachloride of a specific gravity that is needed according to the flows induced in the main. All joints and connections on the hose are inspected to see that they are absolutely water tight.

A flow is then induced in the main by wasting water at the third fire plug and the amount wasted is measured by means of an accurate meter and checked by the use of a hydrant pitot blade and also by means of a pitometer rod. During the gauging of the quantities of water drawn, the deflections at the U-tube are measured. This deflection is used to calculate the amount of pressure head lost between two fire plugs.

This work is done after 12 midnight when little or no consumption is encountered during the test. All side street valves and large connections that may occur between the three fire plugs are closed tight, to make sure that the same amount of water is measured that passes the two plugs where the head loss is being recorded.

After having obtained the quantity flowing per minute and after determining the head loss per 1000 feet of pipe and knowing the size of the main, it is then a simple procedure to obtain the "C" by use of the hydraulic slide rule.

Upon the tests made it was found that the quantity measured by means of the hydrant pitot blade and a velocity type of meter checked within 1 per cent of each other and that of the pitometer rod

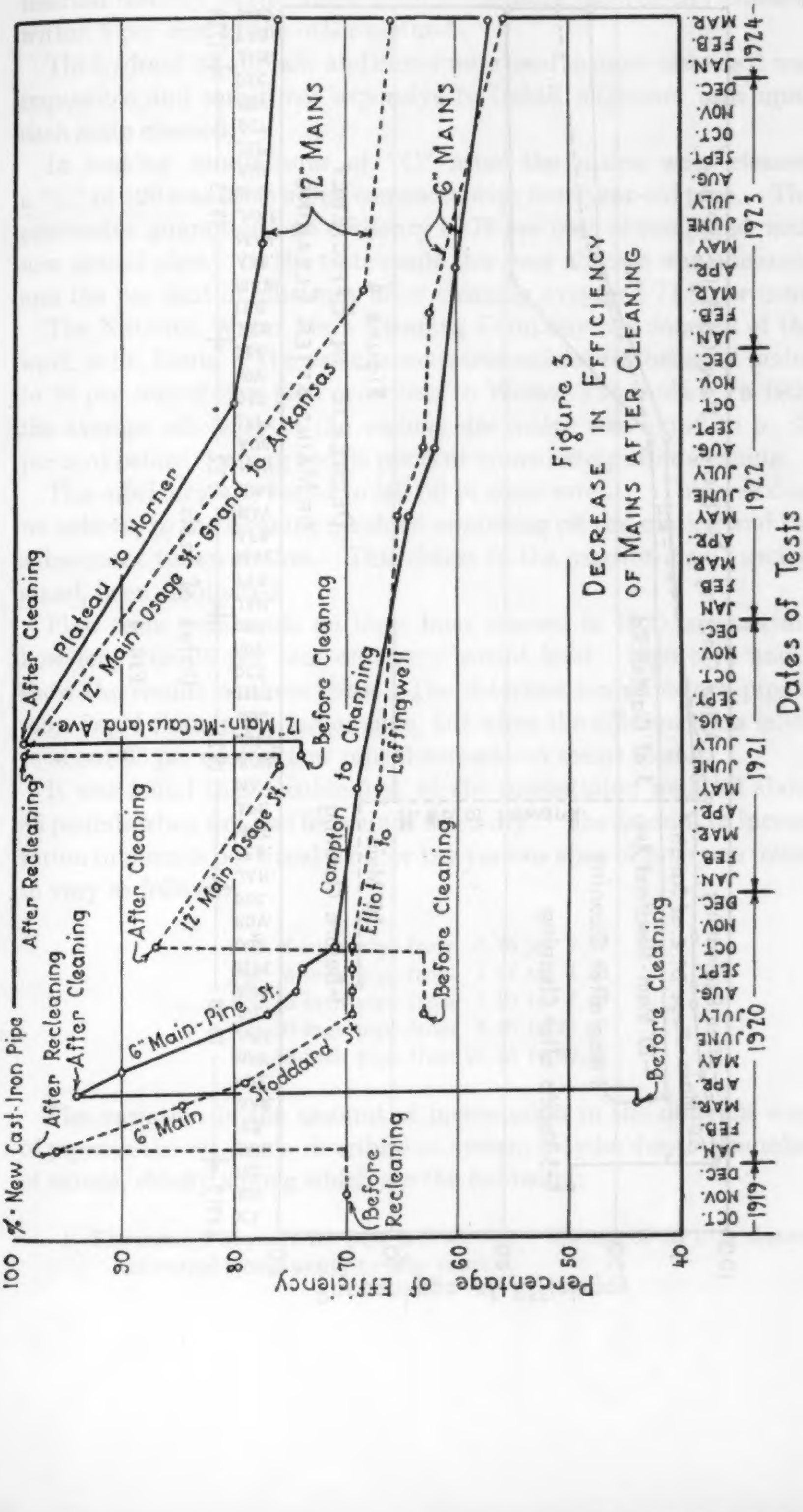
Figure 3
Decrease in Efficiency of Mains after Cleaning
12" Mains
6" Mains
Plateau to Horner
12" Main Osage St.-Grand to Arkansas
12" Main-McCausland Ave
12" Main Osage St.
6" Main-Pine St.
6" Main
Stoddard St.
Compton to Channing
Elliot to Leffingwell
After Cleaning
Before Cleaning
After Recleaning
Before Recleaning
% - New Cast-Iron Pipe
Percentage of Efficiency
100
90
80
70
60
50
40
Dates of Tests
1919
1920
1921
1922
1923
1924

Fig. 3

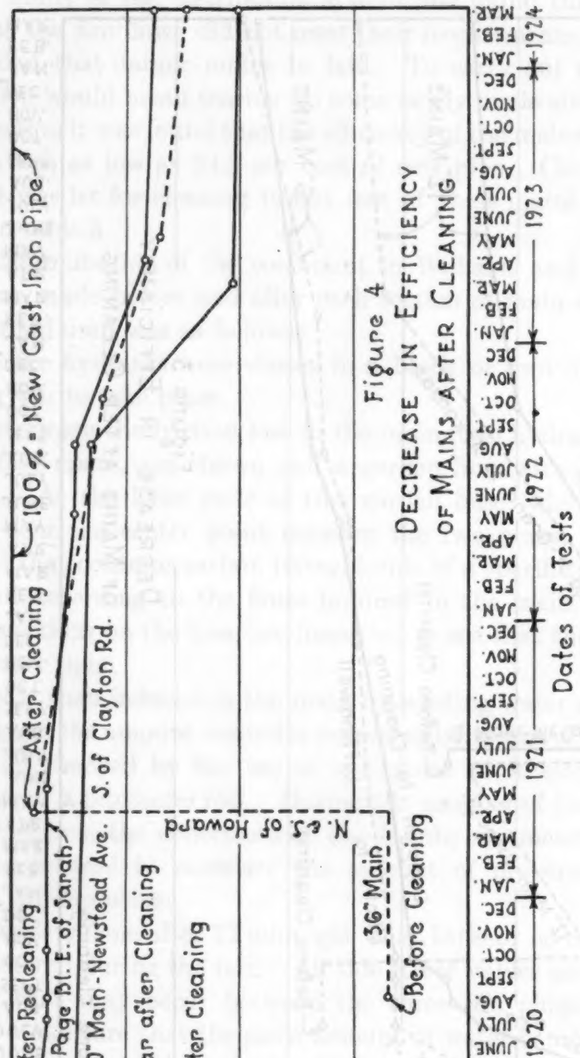
Figure 4
DECREASE IN EFFICIENCY
OF MAINS AFTER CLEANING
Percentage of Efficiency
100
90
80
70
60
After Recleaning
After Cleaning
100% = New Cast Iron Pipe
20" Main - Page Bl. E. of Sarah
20" Main - Newstead Ave.
S. of Clayton Rd.
1-Year after Cleaning
3-Months after Cleaning
36" Main
N. & S. of Howard
Before Cleaning
1919
1920
1921
1922
1923
1924
OCT.
NOV.
DEC.
JAN.
FEB.
MAR.
APR.
MAY
JUNE
JULY
AUG.
SEPT.
Dates of Tests

FIG. 4

inserted directly in the water main to measure the velocity checked within 5 per cent of the other methods.

The hydrant pitot blade and meter were used in most cases as it was impossible and sometimes expensive to install pitometer taps upon each main cleaned.

In making comparisons of "C" after the mains were cleaned a "C" of 120 was used which compares with four-year-old pipe. The contractor guaranteed an efficiency of 79 per cent as compared with new coated pipe. In the tests made this year all pipe was uncoated and the per cent of efficiency after cleaning averaged 71.8 per cent.

The National Water Main Cleaning Company has done all of the work in St. Louis. The various contracts call for restoring all mains to 90 per cent of new pipe according to Weston's formula. In 1920 the average efficiency of the various size mains was found to be 49 per cent before cleaning and 95 per cent immediately after cleaning.

This efficiency was found to fall off to some extent. This was due, we believe, to the cleaning machine scratching off the coating and the subsequent tuberculation. This defect in the machine has, I understand, been eliminated.

Flow tests were made on three lines cleaned in 1920 to ascertain how long the 95 per cent efficiency would hold. Figures 3 and 4 show the results of these tests. The deterioration on 6-inch pipe is more rapid than in the larger sizes, but when the efficiency has fallen to about 65 per cent of new pipe deterioration seems to stop.

It was found that a cubic foot of the incrustation weighed about 85 pounds when wet and 68 pounds when dry. The amount of incrustation in pounds per lineal foot for the various sizes of pipe was found to vary as follows:

For 6-inch pipe from	0.76	to	3.67
For 8-inch pipe from	1.64	to	3.33
For 12-inch pipe from	1.80	to	4.40
For 20-inch pipe from	3.50	to	28.00
For 36-inch pipe from	22.25	to	69.17

The variation in the amount of incrustation in the different sizes of pipes in the St. Louis distribution system may be due to a number of causes, chiefly among which are the following:

1. The number of years the pipe is in service. The age of the pipe cleaned has varied from twenty to fifty years.

2. The character of the water flowing through the pipes. This has varied from a river water purified by plain sedimentation to one purified by sedimentation with coagulation and finally to one purified by sedimentation with coagulation and filtration.
3. The velocity of the water in the pipe. In the trunk mains of the St. Louis system the velocity varies as follows in the mains in different localities.

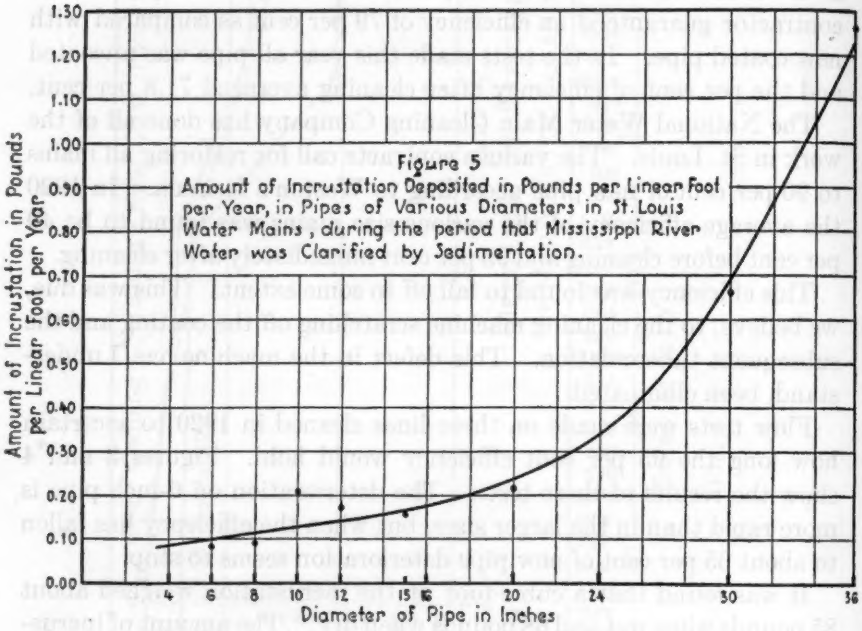

FIG. 5

In 36-inch mains from 0.97 to 4.14 feet per second
In 30-inch mains from 0.24 to 3.00 feet per second
In 20-inch mains from 0.51 to 4.11 feet per second
In 12-inch mains from 0.22 to 2.38 feet per second
In 6-inch mains from 0.10 to 2.00 feet per second

4. The proximity of the main to the pumping station. The pumping stations are located in the northern part of the city while the distribution system extends to the extreme southern and western parts, the maximum distance that the water is distributed being in excess of 10 miles.
5. Dead ends. As our distribution system contains high and low pressure districts, there are a large number of separation valves in the system which cause dead ends.

6. **Pockets or inserts of a large size pipe between two smaller ones. There is very little of this in St. Louis, but there are a few cases where for the sake of economy or other causes, a large abandoned trunk main has been connected up on either end to a smaller one.**

A study was made of the data at hand on the amount of incrustation in the different sizes of pipe. By converting the total amount of incrustation into pounds per lineal foot per year and eliminating data obtained after filtration was started, the curve shown on figure 5 was obtained.

THE CONSTRUCTION OF THE DISTRIBUTION SYSTEM[1]

By C. L. Ehrhart[2]

In the past less care was sometimes used in the construction of the distribution system than of any other part of the water works system. This may have been due to the fact that the work was soon covered and out of sight, or to lack of experience in good construction practice. Whatever the reason it has resulted in much trouble at a later date, often at the most inopportune times. In many cases where the pipe has been blamed for a break, investigation has proven that poor construction practice was at fault.

More care is now used in pipe laying, insuring fewer cases of trouble with the consequent disturbance to service and the useless expense of the repairs. However, very little appears in standard works on the subject of distribution construction practice. Even the American Water Works Association Manual barely touches upon this very important matter. With other water works department practices receiving so much attention, more thought should be given to the distribution system. The writer takes this opportunity of contributing some of his exepriences along this line hoping that they may be of some benefit to others.

While water departments may use various methods in securing, pumping or treating its supply, practically every water works serving a municipality has a distribution system more or less similar to its neighbors and with the same problems of construction. It will be assumed that the design of the proposed project is according to good practice and that the materials have been ordered. The first operation, therefore, is the handling of the pipe from the car.

HANDLING THE PIPE

Under no circumstances should pipe be allowed to drop or swing against anything that will cause it to crack. It should be handled by means of skids, or, better yet, by derricks or cranes which can

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.
[2] Superintendent, Water Works, Council Bluffs, Ia.

swing it clear of all obstacles and deposit it without undue jar wherever required. For use in handling small pipe, the writer has found the best method to be by means of a derrick having a 10-foot boom and mounted on a heavy truck. This derrick is of a type generally advertised, is inexpensive and can be used for handling many things other than pipe. Such a derrick can even be mounted on the side of a freight car, if it is not convenient to mount it on a truck, and then taken down after the car is unloaded. As soon as the pipe is lifted from the pile, it should be sounded for defects, then swung around and lowered. It is not always possible to lower the pipe directly to stock piles, but several lengths may be laid crosswise on the truck back of the derrick and taken over to the stock pile and put in place quickly. Probably the handiest and neatest stock pile is one in which the pile alternates in the placing of the bell and spigot ends with each layer turned 90 degrees in direction. Such a pile is not liable to slip causing breakage or accident and is handier to check. Many times the pipe can be loaded directly to the trucks or trailers and taken to the point where it is to be laid. In the case of large pipe it is often economical to have some company equipped with large stationary booms do the handling. In Council Bluffs we are fortunate in having a bridge company which will unload large pipe to our trucks and trailers at $5.00 per car.

It is most economical to deliver pipe to the job by a truck pulling a trailer where possible. Trailers are rather inexpensive affairs and no water department should be without one or more. All that is necessary to get a good trailer is to buy the running gear of a truck which has been junked, and then place a tongue in it, which will allow it to trail. We have been able to haul from 4 to 5 tons on a single trailer in addition to the pipe on the truck. In removing pipe from truck or trailer to the ground, care should be taken that there is no chance of breakage. On dirt streets it is possible to slide the pipe off the end without damage, but on paved streets such a practice cannot be carried out. We have found it best to lower pipe on paved streets with the above mentioned derrick mounted on a truck. As this truck is also used in lowering the pipe into the trench, it is not necessary to string the pipe with the bell ends one way, for it is a small matter to swing a pipe around when suspended from the boom. We have also had occasions when it is not advisable to string the pipe at all, but to pile it on the parking at convenient locations. In this way it can be stored longer without complaint from the public and

without the danger encountered by stringing the pipe in the street. As the pipe has to be picked up by the truck for placing in the trench, the short run necessary to take it from the pile to the trench, does not noticeably hold up the work as would be the case of handling by hand.

METHOD OF EXCAVATION

With the material on the ground, the next operation is making the excavation. Some of the larger cities are fortunate enough to have trenching machines, but in the smaller or medium sized cities much of this work is done by hand. In either case the trench should be dug wide enough to allow the back filling material to slip past the pipe and fill the lower quarters below the pipe. If a ditch is cramped for width, the back filling material is likely to rest upon the top of the pipe causing an undue strain and possible breakage. If the trench is wide enough to allow proper back filling, it is also wide enough to work in comfortably. In the northern part of the United States the depth of the trench is generally regulated by the frost line, the cover being sufficient to insure against freezing. This cover is generally enough to properly cushion the pipe against excessive weight and consequent strain.

Proper tools should be provided for the excavation work. In cases where it is necessary to go through paving or hard dirt surface, we have found that the cut can best be made with busters or spades operated by compressed air. The compressor is one of the handiest tools the water works man can have, as it takes care of a great many hard jobs which are expensive to handle by hand. While it is better to have a compressor of at least 100 cubic feet capacity, smaller ones may be purchased and mounted on a truck and driven from the drive shaft. It is often possible to get a cheaper compressor by making over a secondhand gasoline engine into a compressor. The first one ever operated by the writer was made from an abandoned six cylinder Buick engine mounted in line and driven by another gas engine. The larger compressor should be purchased mounted, or mounted on the running gear of a secondhand truck and used as a trailer. To avoid undue jar to the compressor, the running gear should have good springs and at least solid tires, if pneumatic are not available. All the tools in excavation work should be kept in good condition, and the spades and shovels should be of a light high grade steel. The best shovels and spades are the cheapest in the long run and are not so tiring to the workmen due to their lightness.

The trench which is to receive the pipe should be graded with a string line the same as for sewer work making the high and low points come at hydrant locations, if possible. This will insure that the sediment can be blown out at the low points and the air taken out at the high points preventing the line from becoming air bound. If the walls of the trench being dug are dry and of the right material, no bracing will be necessary. However, sandy or wet material will require bracing in order to make the trench safe and allow the placing of the pipe. Water in the trench should be removed before attempting to place any pipe. Formerly this was taken care of by hand trench pumps, but the gasoline driven units are now so inexpensive that no pipe laying crew is complete without them. Clear water may be removed by motor driven centrifugals to good advantage. In laying out trenches it is a good plan to keep at least 5 feet away from other parallel trenches, if possible, so avoiding the chance of the ditch on the side near the parallel trench caving in. Such cave-ins generally come without warning and are apt to be serious. Formerly when it was necessary to roll the pipe into the ditch, it was customary to pile all the dirt on one side of the trench. This sometimes created cave-ins because of the excessive weight of the dirt. Where the pipe is handled by derricks or cranes, it is not necessary to keep one side of the trench clear, but it is better to divide the dirt and thus spread the weight on both sides of the ditch. In the past it has generally been customary to dig the bell holes as the pipe was placed in the trench. However, where portable trucks are used it is possible to lay from 10 to 12 lengths per hour, so the bell holes cannot be dug after the pipe is in the ditch without delaying the work. Under such conditions it is better to measure off the bell hole locations and have enough men digging bell holes so as to insure no delay in the pipe laying.

PIPE LAYING

With the trench ready to receive the pipe, it is important that the laying proceed as fast as possible. With the portable truck derrick the pipe should be raised with the sling around the middle so as to keep it balanced. As soon as it is clear of the ground, the pipe should be given a final sounding to prevent defective or cracked pipe from entering the ditch. The derrick is then run alongside the ditch, the boom swung around and the pipe lowered. In the meantime one man should clean and dry very thoroughly the bell of the last pipe laid as many defective joints are caused by dirt or foreign matter.

When the next pipe is lowered the same man should also clean the spigot end. He should then place a strand of hemp around the pipe and guide it into place when it is sent home. The best hemp to our notion is of the dry braided type, and two strands are usually sufficient. Should the pipe pinch to one side as it is being entered, it is easy to swing it from side to side or raise it with the derrick until the hemp is driven home and the spigot end properly centered in the bell.

In cases where it is impossible to use a derrick, the pipe may be lowered into the trench by means of a rope at each end with a rolling hitch, one end of each rope being held under the feet of the men lowering, and the other end paid out as evenly as possible so as to lower the pipe without dropping. In this way two men can lower a length of pipe. For sizes too heavy for lowering by hand, a four-legged derrick can be used, or even better a large crane or drag line.

After the spigot end of the pipe is home and yarned, the joint should be prepared immediately for the joint material as delay may permit foreign matter to enter. We believe it is best to use a square running rope with a clamp to tighten it up. We have also found it best to seal this running rope against leakage by the use of fire clay rather than ordinary clay. Fire clay may be used over and over again and is not expensive in the long run. After the running rope is sealed, a gate should be built up depending upon the materials used for joint purposes. Either lead or lead substitutes require heating, and while formerly the kettles were heated with a wood or coal fire, it is much better to use a kerosense burner as it will heat the material quickly and once heated will hold it in readiness for use insuring against delays caused by cold material. The joint material should be handled carefully so as to avoid spilling and the possible injury to workmen. The pouring of the joint should be done continuously, and, in case one pot will not run the joint, additional pots should be in readiness to carry the pouring out with the least break in time. Immediately after the pouring of the lead, it should be caulked to take up the shrinkage caused by cooling. Formerly most of this work was done by hand, the caulker running around the pipe first with a chisel following up with the cauling irons using the small ones first. However, if compressed air is available, this method should be used in caulking. Compressed air driven joints are better than hand driven as the lead can be taken up from $\frac{1}{8}$- to $\frac{1}{4}$-inch more than by the hand method without any danger of splitting the bells. Such joints are superior as the last one driven during the day is as good as the first, whereas

the quality of hand caulked joints is liable to lag during the latter part of the day. Furthermore, where the pipe is being laid in large quantities it is absolutely necessary to caulk by air in order to keep up with the laying crew. Sometimes on the larger joints the lead fails to pour evenly causing a crack in the joint, but this may be remedied by caulking lead wool into the spot where the break occurs.

At times unavoidable conditions cause the joints to become wet, and extreme care must be taken in pouring such joints. Before pouring the lead a quantity of coal oil should be poured into the joint, followed immediately by the lead. In place of the coal oil, lubricating oil or candle shavings may be used with equally good results. It is also a good plan to make a small hole with a knife in the bottom of the joint for drainage purposes. This may allow a little lead to run through, but it will soon freeze at the point of drainage and pour properly. When the pipe is finally placed in the ditch, it should not rest on any solid or unyielding projections, but should lie evenly so that it will not be subject to any strain as every strain is a potential trouble maker.

CUTTING PIPE

The writer has seen many cases of poor pipe cutting caused by awkward methods. A pipe can be cut fairly evenly if the work is done right. Before attempting to make a cut the pipe should be marked at the exact distance from the end by means of a tape or rule. It is then possible to place a running rope or even cloth tape around the pipe at this point, after which the whole circumference of the pipe may be marked very easily. A cross mark should be made to show the starting and ending points of each turn of the pipe. The pipe should then be placed on a heavy timber with the cutting line directly over the middle of this timber. Starting at the cross mark a slight cut should be made using a sledge and hardy. When the cross mark is reached the pipe should be rolled back to the point of beginning after which a second and heavier line may be cut with the hardy. By rolling the pipe back and starting at the cross mark each time, the strain will be kept equal. Finally the pipe will become crystallized to the point where it will snap off fairly evenly without projections exceeding $\frac{1}{4}$-inch. In making cuts on larger pipe it is a good idea to make the first round with a diamond point as this removes a considerable amount of the material. Then by following with the hardy, as above mentioned, the pipe will crystallize and crack. Cutting old pipe in the

ditch has been more or less difficult, particularly in the large sizes. When the cut was made with regular cutters, the pipe was generally bound in place even after the cut at both ends was complete, making it necessary to break the pipe, which was often hard to do in the larger sizes. There is on the market at the present time an oxy-acteylene outfit having a special torch for burning cast iron pipe, and we have found this to be the handiest method of cutting pipe in the ditch, as the cut is at least ¼-inch wide, and the pipe is free as soon as the cuts are made. To secure the best results with such an outfit, the pipe should be drained as water in the pipe tends to carry away the heat. It is also best to make the first round with the diamond point as any chalk marks are burnt off by the hot flame, while the track made by the diamond point can be readily seen.

VALVE AND HYDRANT DISTRIBUTION

Every distribution line should be properly valved. Most of us have had occasions when we would have given much to have had valves at the proper locations. These valves should be spaced so that a minimum amount of main is thrown out of service whenever it is necessary to work on the line. Not only is this according to the Underwriters' specifications, but it prevents the needless shutting off of house service. If the Underwriters' rules are followed, the system will always be properly valved. In setting valves a concrete base should be provided so that there is no chance of the valves settling. We have found concrete from old sidewalks to be ideal for this purpose. Every valve must necessarily be provided with a valve box or manhole so that shutoffs may be made quickly. The question of whether to use boxes or manholes is more or less optional in the small sizes, but valves larger than 12 inches should always have the manholes.

Hydrants should be set at least not further apart than each street intersection, and in the business district, or in the residence district where the intersecting streets are too far apart, additional hydrants should be set in the middle of the block. The business district at least should be equipped with steamer hydrants, and it is better if the residential districts can also be equipped with the same, although the necessity is not so great. In placing hydrants care should be taken that the hydrant is kept far enough back of the curb to clear all automobile bumpers, and it should be set high enough so that the fire department will experience no difficulty in making the hook up

by reason of dirt or snow being too close to the caps. The writer has seen many hydrants set at crazy angles and has made it a point that all hydrants set under his direction were properly plumbed. After plumbing, the hydrant should be braced near the top with temporary wood braces to hold it plumb while the back filling material is being tamped in place. The hydrant should have a base of concrete similar to that used for valves, and it is most necessary that the space back of the hydrant to solid ground be filled with concrete to prevent the hydrant from blowing off. No wood should be allowed in these braces as it will rot and allow the hydrant to push away. At least a bushel or more of brickbats, preferably of soft brick, should be placed around the base of the hydrant to take care of the drainage water. If it is not provided, the hydrant will not drain and will probably freeze. The writer has never set a hydrant without an auxiliary valve in front of it. The expense is not great and is justified, as it allows the hydrant to be repaired without interference to service. Hydrant connections should be not less than 6 inches in diameter and the hydrant should preferably be of the same size.

TAPPING MAINS

Connecting new lines at right angles to old lines not provided with tees or crosses, naturally necessitates a tap which may be made in two ways, by means of a machine, or by cutting out a section of the pipe and setting in a tee or cross. When made by machine, care should be taken that the split sleeve is centered evenly around the pipe and that there are no defects in the joint. The sleeve should be carefully leveled before the joint is run. After the tee is in place and the joint caulked, the machine should be hooked up and the cutting started. The pilot cut is easily made, but the main cut takes considerable labor, and it is of importance that the cutters be sharp and all ground to an even length, otherwise the cutting will be uneven and exceedingly hard to make. After the cut is made and the piece drawn out, the valve should be closed and the machine removed, after which the laying of the pipe may proceed in the ordinary manner. In cases where it is necessary to insert a tee or cross, a section of the pipe should be taken out, after which the fitting may be set in place and the opening closed by means of a short length of pipe and a sleeve. Where the sleeve is placed a small section of the pipe is generally missing due to the fact that it had to be cut short in order to enter the bell. Should a valve be placed close to this point and the pressure

applied to one side of the valve only, there is a possibility of the valve pushing toward this open space, and opening up a joint at the valve. This space may be eliminated by cutting a very short section of pipe and dropping it in the opening before the sleeve is set.

Fittings such as tees, elbows and plugs must be properly braced against solid earth in a manner similar to the bracing required for a hydrant. If such bracing is not placed, the chances are that the pressure will open up a joint or crack a pipe near the fitting. Sometimes it is necessary to brace back a considerable distance, and we have found it very convenient to use old pipe between the fitting and solid earth in such cases.

PRESSURE TEST

At the completion of each block of pipe, a test should be applied to prove that no defective pipe or joints are in the line. Formerly when central station pressure was carried for fire service, it was necessary to make what you might term a high service test, but since the advent of the fire department pumper, the policy of putting on additional pressure has practically disappeared so that we feel safe in using domestic pressure for our tests. If possible test plugs should be provided so as to make it convenient for removing the air in the line and also for removing the plug when the test is completed. However, if test plugs are not available, an ordinary plug may be used with a lead joint shallower than normal. In cases where oxy-acetylene outfits are available, these joints may be melted very easily.

BACKFILLING

Backfilling may be done by machine, by hand back filler and team, or by hand, and the relative cost and speed is in the above order. Naturally a machine back filler is preferable, although the use of a hand filler and team does not cost so very much more. Hand backfilling is expensive and should not be practiced, if possible. We have found it best to pile all the dirt over the ditch, and after it is filled to flush the ditch. If this flushing is done from above, the results will be poor and incomplete as the dirt will wedge part way down in the trench, and the bottom of the ditch will not be properly settled. The best method of flushing is to place an 8-foot pipe on the end of the hose and push this pipe into the ditch until it hits the water main. Then allow the water to flow until it shows up at the top of the ditch, after which the pipe may be moved forward about ten feet.

This method is more efficient and better than hand tamping. We have taken a hand tamped ditch and applied the flushing in this manner and caused the dirt to settle several inches. Practically all the dirt that has been thrown out, except that displaced by the pipe, may be replaced in this manner.

RECORD

The cost of laying a water main should be checked from day to day in order that everybody concerned is fully conversant with the results. The foreman on the job can practically make or break the contractor as regards costs. If he is in sympathy with the idea of economy and efficiency, and uses his head in planning his work and arranging his men, he can get good results at moderate costs.

With the job complete, a record should be made showing the length, depth, location of specials, hydrants, valves and any other data of value in the future. This record should be placed on a map and filed away in a fire proof vault or safe. Card indexes should be made in duplicate showing location of all valves and hydrants, one set kept in a fire proof place, and the other set kept convenient for instant inspection. Unless this is done, the project cannot be called complete.

CRENOTHRIX IN GROUND WATER SUPPLIES[1]

By Kenneth W. Brown[2]

Ground waters are frequented by comparatively few microörganisms, but, when encountered, they are often accompanied by a multiplicity of troublesome conditions. The most common offender is Crenothrix, a member of the co-called "iron bacteria" family, so named because of their association with considerable quantities of iron.

Iron bacteria, requiring organic food, are generally found in waters rich in iron and organic matter, a condition often found in wells driven in swampy land. Crenothrix is a small filamentous plant with cells only slightly larger than bacteria, which grows attached to well and pipe walls and in the voids of porous strata. Any part of a ground water system, therefore, is subject to infection with this organism.

Ground waters, usually deficient in dissolved oxygen content, carry, on the other hand, relatively high concentrations of carbon dioxide, although iron bacteria do not utilize this gas for their life processes. Water containing comparatively large amounts of carbon dioxide exerts a solvent effect on iron and carries it in solution in the ferrous condition. Presence of the filamentous bacteria, which possess the power of oxidizing iron in this form, causes its precipitation in the ferric state.

The existence of Crenothrix is, more often than not, accompanied by a variety of ill effects, of which taste, odor and discoloration are the most potent. A noticeable turbidity is caused by the precipitated ferric oxide or hydroxide. When the plant is growing sparingly, and is all in the living state, the odor is thought to be due to release into the water of an oil which is secreted by it. At later stages, during time of luxuriant growth and consequent dying off of the organism, the foul and offensive odors of disintegration are ex-

[1] Presented before the Water Purification Division, the San Francisco Convention, June 13, 1928.

[2] Sanitary Engineer, California Water Service Company, Stockton, Calif.

perienced. This is due to decomposition in the absence, or relative absence of oxygen, of organic matter contained in the dead bodies and encasing gelatinous sheaths of the organisms. At such times, particularly in the neighborhood of distribution system dead ends, an epidemic of discolored and malodorous water is more than probable. Naturally, of course, such conditions arouse a variety of complaints, some of which are chronic, others are violent, and some few are intelligent.

Still another effect of Crenothrix growths, one equally as important but accorded less consideration, is that of decreased pipe capacity. This is caused by either or both of two processes, iron precipitated by action of the organisms deposits in the pipes and, secondly, the filamentous forms grow in tufts which become matted together in felt-like layers adhering to pipe interiors. The very considerable hydraulic significance of these linings, often ½ inch thick, is obvious.

Little information is available regarding the influence of Crenothrix on pipe corrosion. Possibly, pipes lined with growths of this organism are immune from attack due to protection afforded by the interior lining. However, it can also be argued that the plant assists corrosive forces. During periods of decomposition and consequent evolution of carbon dioxide, there exists, as a result, a situation tending to accelerate corrosion. No definite statement can be made as to which force exerts the greatest influence although it is believed that, in all probability, the magnitude of either is governed by other factors.

PECULIAR PROBLEMS IN CALIFORNIA SYSTEMS

Previously published descriptions of the control and destruction of Crenothrix infections have dealt with water supply systems operating central pumping stations and purification plants. Under such circumstances it is possible to initiate means of treatment which, generally speaking, enjoy possibility of success. In California systems, however, with which the writer has had experience, the distribution mains are often supplied from wells in scattered locations. The problem of treatment is further intensified in that the automatic deep well pumps discharge directly into the distribution system.

Iron removal, in itself not always easy nor entirely satisfactory, is out of the question on account of the scattered arrangement of pumping plants. Systematic flushing, requiring a rather considerable labor expenditure, affords benefits that are merely transitory,

and is of little effect in so far as improving general community opinion of the water's wholesomeness is concerned. Under such circumstances it becomes necessary to combat Crenothrix growths by methods that are, at least, comparatively inexpensive. All of which necessitates control or elimination by application of chemicals.

Redondo

At our Redondo plant we have a Crenothrix infested well discharging through a sand box to a storage reservoir. Until about a year ago somewhat inadequate control of the situation had been realized by means of treatment with copper sulfate and chloride of lime. The chemical solutions were prepared in oak barrels and fed directly to water passing through the sand box. This cumbersome and inaccurate system was replaced by a direct feed chlorinator. Following inauguration of chlorination at a rate of 0.60 p.p.m., we received an unusual number of complaints, but these lasted only four or five days, after which adverse comment was more or less of a rarity. Reduction of the dosage to 0.40 p.p.m., so as to avoid possible waste of chlorine, resulted in equally pleasant conditions. Attempts to further decrease the rate of feed were less successful as indicated by an apparent tendency toward poorer quality of water with respect to taste and odor. This spring, however, we experienced a revival of obnoxious water, particularly in one section of town located at a somewhat higher elevation than the average. As a result, it was decided to try disinfection of the offending well by pouring into it about 100 pounds of copper sulfate in solution. Introduction as a solution checks the possible action of crystalline copper sulfate on the well casing. After twenty-four hours the well was pumped to waste until clear water was obtained which, in this case, required a period of about forty minutes. It should be noted that the efficacy of well sterilization in this manner is largely a matter of chance. The age and extent of Crenothrix infection, and location with respect to direction of ground water flow influence susceptibility to treatment. That such radical procedure is worthy of trial has been demonstrated at Redondo. Tufts of iron colored Crenothrix bearing material discharging from the well have been eliminated and complaints have practically ceased.

Bakersfield

At Bakersfield we encounter, in some sections of the system, an annual epidemic of black water. The fact that these occur each

spring leads one to the belief that they are indicative of seasonal changes in pipe growths of filamentous organisms common to ground waters. The recent disturbance at Redondo, also happening in the spring, is further evidence in favor of this theory. Disintegration of the plant at this time of the year is doubtless responsible for the unwholesome and discolored water. Remedy at Bakersfield has always been obtained by intensive flushing of the affected area for about two or three days. The community, at times other than this, is entirely unconcerned with the quality of water.

Port Costa

We have, in the Port Costa system, a rather peculiar well that has been the source of considerable difficulty. This well, drilled in more or less swampy formation, is about 480 feet deep and has a capacity of 230 gallons per minute. Water pumped from it through a weir box to a storage reservoir carries large tufts of filamentous growths. This material is expelled in sufficient quantity to necessitate installation of a screen box for its removal. Two screens, 4 by 4 feet, of ¼-inch and No. 14 mesh respectively, are effective in removing practically all of the offensive appearing flakes. The system of screens is provided in duplicate so as to permit washing without interrupting operation. After passage through the screens the water is treated with copper sulfate and chlorine, applied in the weir box at rates of 0.50 and 0.25 p.p.m., respectively. Although material washed from the screens produces foul and offensive odors as a result of decomposition, complaints regarding taste and odor have been entirely absent

Stockton

The most obdurate and treatment-defying ground water supply we have is that at Stockton. At the principal pumping plant, nine deep well pumps discharge through four inlets to a 2 million gallon reservoir, from which water is pumped to distribution. Three other stations have a total of five automatically operated deep well pumps discharging directly into the system.

Microscopic examination of pipe samples collected from numerous locations indicated Crenothrix infection to be universally prevalent throughout the system. Leptothrix, a somewhat similar organism, was also observed in some abundance.

About eight years ago, following replacement of existing suction

lift pumps with deep well equipment, the reservoir became infested with heavy filamentous growths and, at the same time, taste and odor became unduly apparent.

To combat these conditions, application of copper sulfate, followed by intensive flushing, was begun. This practice is still in effect, although flushing is confined to that necessary to relieve complaints, which are quite frequent in the vicinity of dead ends. The chemical is fed in solution to the main suction line at Station 1 at an approximate rate of one part in twenty million. Obviously, this is a minute dosage and is of doubtful value, if any. It has not been increased, however, due to lack of authentic information regarding the toxic effect on the human system of copper salts applied to water pumped directly to distribution. Reservoir growths have been successfully inhibited by spraying the walls twice weekly with a solution of bluestone. This solution, consisting of 6 pounds of copper sulfate in 15 gallons of water, is sprayed from equipment transported by boat. Water in the reservoir is lowered each time in order to expose the walls sufficiently.

Disinfection of two or three wells with bluestone in the previously described manner has been attempted, but no particularly beneficial effect has been observed. In this instance it is probable that subterranean conditions are not susceptible to such treatment.

In order to investigate the feasibility of cleaning water mains by chemical means, we removed two sections of 4-inch pipe from service and subjected them to treatment. A solution containing 0.30 p.p.m. of available chlorine was passed through one section for a period of five days at a rate of 150 gallons per twenty-four hours. Examination of the pipe at the end of this time revealed no appreciable diminishing of the original half inch interior lining. This is contrary to results of experiments conducted by Stevenson at Marysville who reports successful cleaning of Crenothrix lined pipes with solutions containing 0.20 p.p.m. of free chlorine. The second section of pipe was treated at the same rate, 150 gallons per day, with water containing 0.50 p.p.m. of copper sulfate. At the end of five days it was found that the majority of adhering material had been successfully removed, demonstrating thereby that chemical removal of conduit growths is not without possibility. The somewhat unsatisfactory nature of these results, as evidenced by the time and dosage required, has led to the abandoning of plans for cleaning the distribution lines by such means. It had been planned to isolate sections of

pipe, dose them with chemical, and flush thoroughly at a high rate of flow before replacing them in service.

A somewhat unusual opportunity to study the Stockton problem presented itself several months ago. A local swimming pool using city water, for over a year, had been experiencing badly discolored water. This was caused by the precipitation, some twenty or thirty hours after filling, of an iron colored amorphous substance which completely covered the bottom of the pool. Naturally, disturbance of this material produced an appearance which was, to say the least, uninviting. Believing this condition to originate within their own system, the management indulged in a thorough house cleaning and attempted various other methods of improving the situation, but to no avail. Finally, their woes were voiced to the water company. Microscopic examination of the precipitated material immediately showed the presence of filamentous algae, thus demonstrating conclusively the source of trouble. Large mains in the neighborhood were flushed as a primary remedial measure, but this failed to obviate even slightly the difficulty. The next step was to place a weighed amount of bluestone in a burlap sack and suspend it in the pool influent at the time of filling. This dosage, which amounted to 1.5 p.p.m., proved entirely effective in preventing deposition of the Crenothrix bearing material. Sometime later the management essayed economy by cutting the amount of chemical in half which, as was to be expected, brought about reappearance of the discolored water. Return to the original prescription again produced water of satisfactory appearance. Similar excellent results were obtained by means of an experimental chlorinator installation employing a dosage of 1.0 p.p.m.

CHLORINATION EXPERIMENTS

The efficacy of copper sulfate and chlorine in inhibiting precipitation in the pool established beyond question the ability of these chemicals to control Crenothrix conditions. Although no limit has been defined as to the amount of copper salts safely applicable, it is considered advisable, in view of their known poisonous quality, to avoid their use whenever possible. The undoubted rapid precipitation of copper as an insoluble compound is no guarantee that it will not ultimately find its way to consumers and thereby exert a toxic effect. Bearing this in mind, it was decided to attempt treatment with chlorine rather than unduly increase the existing practice with copper sulfate. Furthermore, facilities for controlling chlorination are far more adequate and satisfactory.

Installation of chlorine equipment on the main suction line at Station 1, using an initial dosage of 0.25 p.p.m., was the signal for an immediate barrage of complaints. Consumers located on dead ends were particularly disturbed, and not without justification. Reduction of the dosage to 0.20 p.p.m. resulted no more favorably. It was then decided to operate the chlorinator during the day only, shutting down at night as soon as the low flow period occurred. This practice, which has now been in effect for some time, has been attended by little, if any, unfavorable comment. After continuing in this manner for several months it is intended to again chlorinate during the full twenty-four-hour period. Naturally, it is too early to venture an opinion as to the probable outcome of treatment, although it is reasonable to expect some degree of improvement. Chlorination at the remaining stations, which are automatically operated, is not contemplated until sufficient data have been gathered at Station 1. Inasmuch as about 70 per cent of the total pumpage is from this plant, the results obtained should be quite indicative of what could eventually be realized by treatment of the entire system.

SUMMARY

In summarizing our experiences, it appears that Crenothrix infections in ground water supplies can be eliminated by application of either copper sulfate or chlorine in those systems operating pumping plants augmented by reservoirs of adequate capacity. It is advisable, however, in order to avoid occurrence of obnoxious conditions, that introduction of the chemical be made prior to the reservoir. For systems operating a series of scattered wells there is apparently little opportunity of destroying filamentous organisms; resorting to chemical treatment will occasion inevitably distressing features, the extent of which cannot be foretold. Combating algae by chemical application to water pumped directly to distribution from a system of scattered wells is, therefore, nothing less than a gamble with odds somewhat in favor of the Crenothrix survival.

DISCUSSION

EDWARD C. TRAX:[3] In connection with Mr. Brown's paper a brief description of a Crenothrix plague in Clarion, Pennsylvania, may be of some interest. A hydro-electric development in the Clarion River necessitated the reconstruction of the water plant supplying the town

[3] Chemist and Bacteriologist, McKeesport, Pa.

of Clarion, county seat of Clarion County. The old works consisted of a series of drilled wells along the river shore pumped with an air lift system, a "gathering well," sedimentation basin and mechanical filtration plant. The water from the wells was very good bacterially, but was strongly impregnated with hydrogen sulphide and free carbon dioxide gases, and contained 2 or 3 p.p.m. of iron as carbonate, or possibly sulphide. The air lift pumping and general arrangement of the plant furnished fairly good aeration of the water, which aided very materially in the removal of the sulphuretted hydrogen and iron, and the water was quite satisfactory.

With the construction of the dam which resulted in the submergence of the old plant, ten new wells were drilled to the water bearing stratum from which the water was formerly obtained and a modern filtration plant was constructed along the hillside at a higher elevation. The new wells were equipped with deep well pumps and no provision was made for aeration of the water either before or after filtration.

The water was found to be most difficult to coagulate and the sulphuretted hydrogen and iron removal were not satisfactory. This resulted in a most serious plague of Crenothrix, starting in January, 1925, and lasting for about six months. The odor of the water was most disagreeable, especially the hot water, and it was unsuitable for laundry and other domestic purposes on account of the considerable amount of iron present. White materials washed in the water were badly stained and it was altogether a most unsatisfactory and objectionable supply. The odor may have been due to a combination of the growths of Crenothrix and to the fact that the sulphuretted hydrogen was not thoroughly removed from the water before it was pumped to the distribution system. Although the water furnished was at all times safe for drinking, the natural reaction of the public was to refuse to believe that the evil smelling supply was safe to drink, and well and spring waters, some of doubtful purity, came into general use for drinking purposes.

The solution of the problem was worked out by the installation of an excellent spray nozzle aerator and a mixing chamber with a Dorr mechanical agitator. The water from the wells goes first to the aerator and is then treated with a balanced dose of lime and alum as it enters the mixing chamber; from the mixing chamber it passes to the sedimentation basin and through the plant in the ordinary manner. This installation has proved a complete success and the water furnished is entirely satisfactory.

THE REMOVAL OF IRON FROM HARD GROUND WATERS[1]

By R. L. McNamee[2]

The ground waters of Indiana are characteristic of those of the Middle West. In these regions the rock is overlaid with glacial drift, which contains materials of heterogeneous nature. The percolation of waters downward through this drift results in the solution of various materials and produces ground waters with considerable content of dissolved impurities. Such waters are popularly classified as "hard" and "rusty," the hardness due to the soap-consuming powers of the calcium and magnesium compounds and the rustiness to the iron which appears when the water is used. This paper is confined principally to the problems presented by the presence of iron in ground waters used for public supply.

IRON IN GROUND WATERS OF INDIANA

There are in Indiana over 90 municipalities having public water supplies and populations of 2,500 persons or more. Of these towns, over 60 secure their water from ground water sources. Table 1 concerning these ground water supplies is prepared from analytical data furnished for the purposes of this paper by L. S. Finch, Director of Water and Sewage Department, Indiana State Board of Health.

Six municipalities are using water carrying iron over 2 p.p.m.; 16, from 1.0 to 2.0 p.p.m.; and 11, from 0.5 to 1.0 p.p.m. Iron is usually not objectionable when present in quantities less than 0.5 p.p.m.

The geographical distribution of these iron-bearing ground waters is interesting. Most of the ground waters carrying iron in excess of 0.5 p.p.m. are found in the easterly half of the state. The area is roughly bounded by the Michigan line from near Elkhart easterly to the Ohio line, along the Ohio line from the Michigan line nearly as far south as the Ohio River, thence northwesterly along a line through

[1] Presented before the Indiana Section meeting, February 27, 1929.

[2] Principal Assistant Engineer, Hoad, Decker, Shoecraft and Drury, Ann Arbor, Mich.

Indianapolis to LaFayette thence northeasterly to Elkhart. Toward the center of this area the iron content becomes greater so that in a relatively narrow belt extending from Kokomo easterly to the

TABLE 1

Indiana municipalities of 2500 population or more using ground water supplies, classified as to iron content

Data for the year 1924

Iron over 2.0 parts per million

Dunkirk	6.0	Hartford City	2.5
Bicknell	4.0	Portland	2.5
Marion	3.0	Crown Point	2.2

Iron 1.0 to 2.0 parts per million

Fort Wayne	2.0	New Castle	1.6
Greenfield	2.0	Union City	1.6
Kokomo	2.0	North Manchester	1.4
Rushville	2.0	Angola	1.2
Winchester	2.0	Connersville	1.2
Frankfort	1.6	Kendallville	1.2
La Porte	1.6	Peru	1.2
Nappanee	1.6	Wabash	1.2

Iron 0.5 to 1.0 parts per million

Decatur	1.0	Auburn	0.6
Greensburg	1.0	Bluffton	0.6
Jasonville	1.0	Goshen	0.6
Elwood	0.8	Lebanon	0.6
Franklin	0.8	South Bend	0.6
Gas City	0.8		

There are about 30 municipalities in the water supplies of which the iron is less than 0.5 p.p.m.

state line the ground waters contain normally more than 2 p.p.m. of iron. Dunkirk, about in the middle of this belt, has a water showing 6.0 p.p.m. of iron.

OCCURRENCE AND EFFECTS OF IRON IN WATER

Iron is found in solution in the ground waters of glaciated regions of the Middle West as ferrous carbonate. The soils contain iron as the ferric oxide (Fe_2O_3). Ground waters, especially in deeper strata,

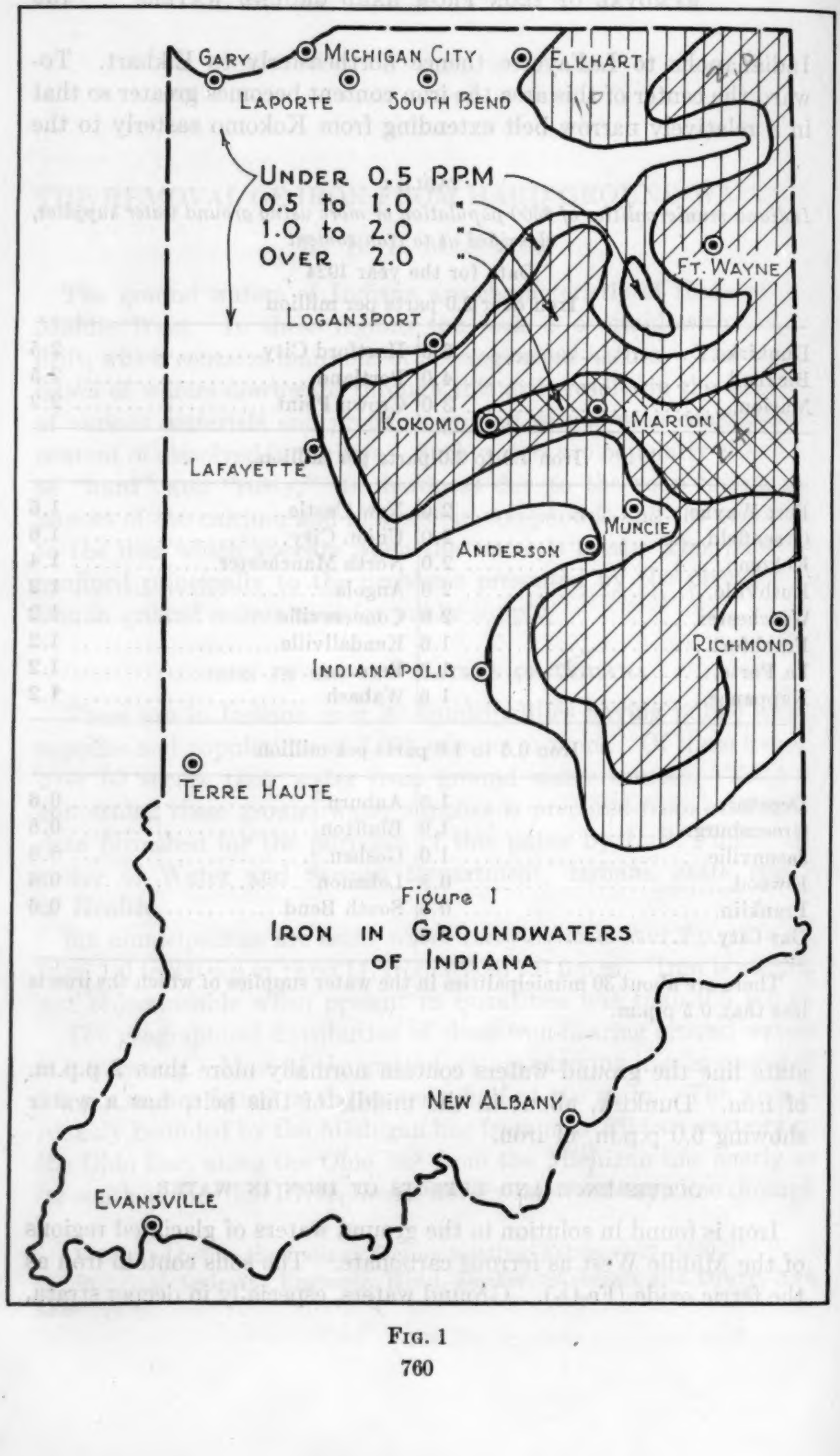
Gary
Michigan City
Elkhart
Laporte
South Bend
Under 0.5 P.P.M
0.5 to 1.0 "
1.0 to 2.0 "
Over 2.0 "
Ft. Wayne
Logansport
Kokomo
Marion
Lafayette
Muncie
Anderson
Richmond
Indianapolis
Terre Haute
Figure 1
Iron in Groundwaters
of Indiana
New Albany
Evansville

FIG. 1

reduce the iron to the ferrous oxide (FeO). Carbon dioxide, common in hard waters, combines with the oxide to form ferrous carbonate. The ferrous carbonate is relatively stable under conditions such that the carbon dioxide is held in solution and oxidation does not take place. But when these conditions are not maintained and the water is exposed to the air as in open reservoirs or when drawn for use, a natural oxidation takes place and the iron reverts to an insoluble state and settles out or deposits upon many surfaces with which the water comes in contact.

The presence of iron fosters the growth of a certain bacterium, Crenothrix, which feeds upon the soluble iron and converts it into the insoluble ferric condition of which its inclosing sheath is formed. Such growths, under favorable conditions may become so large that they may seriously reduce the carrying capacity of water mains and even completely choke services in which conditions are favorable for their development.

The objectionable qualities of iron-bearing waters are common knowledge in Indiana. Plumbing fixtures become stained a reddish brown color where water drips from faucets. Fabrics acquire a yellowish discoloration in the laundering process. Certain industries find it necessary to eliminate the iron before using it. Under some conditions, dyes cannot be applied with waters having iron in solution. Woolens in the process of fabrication are discolored in washing. In the kitchen, also, iron has undesirable effects. Under some conditions it is impossible to brew tea of satisfactory taste. Certain vegetables assume disagreeable flavors when cooked in iron-bearing waters. When the Crenothrix is present, unpleasant tastes and odors are often present in the tap water.

These conditions, or some of them, are noticeable generally when the iron content exceeds 0.5 p.p.m. The United States Treasury Department Standard for drinking waters for use on common carriers in interstate traffic provides that the iron should not exceed 0.3 p.p.m.

METHOD OF TREATMENT

The artificial means of treatment employed to remove iron are substantially the same in principle as those natural processes which cause the precipitation and deposition of iron at the point of use. The treatment generally consists of three processes in series: aeration, sedimentation and filtration. Under certain conditions treatment with a coagulant is necessary in order to secure effective

sedimentation. The aeration is the means by which the iron is chemically changed from the soluble to the insoluble form. The sedimentation is the means by which part of this insoluble iron is separated from the water. Some of it is in such a finely divided state that it will not settle within reasonable length of time for which sedimentation basins may be provided. Filtration through sand is utilized to remove these finer sediments, for which purpose it has come to be an essential element of the treatment.

The removal of iron is not always so simple as this statement of procedure may indicate. The problem varies with the chemical content of the water and is seriously complicated with waters high in organic matter or bearing manganese in considerable amount.

Aeration

The aeration of water is usually accomplished by the exposure of the water to the atmosphere under conditions favorable for its absorption. In a few instances, aeration has been provided by forcing air through the water by means of grids of perforated pipes or diffusers placed at the bottom of tanks through which the water passes. Aeration by such means is provided, incidentally, by the air lift pump, for which purpose this type of pumping equipment is to be preferred for iron bearing ground waters in some cases, over other types. Of all its applications the air lift pump is, of course, best suited to raising water from wells.

A variety of devices have been developed and are being used to facilitate the exposure of water to the atmosphere for purposes of aeration. Essentially they may be classed in three groups; sprays, falls, and contact trays. In many plants, a combination of two of more devices are employed.

Sprays are of several types, from simple orifices in pipes to more complicated whirling nozzles similar to those used for lawn sprinkling. A unique and efficient spray nozzle is that developed for use at the Sacramento water purification plant. The nozzle proper is formed as a bell-mouth facing upward. The throttling is secured by means of a conical casting which is floated by the head of water and which deflects the stream into a thin sheet over a wide radius. It operates well under considerable variations of head.

Sprays of one type or another are employed for aeration at Amesbury, Mass., Griffin, Ga., Lawrence, Kan., Leroy, O., Long Beach, N. Y., Middleboro, Mass., Selma, Ala., Stuart, Fla., and Wadsworth,

O. The plant now under construction at LaPorte, Ind., will use sprays of the Sacramento type.

Falls in their simplest form consist of riffles, sloping surfaces sometimes provided with low baffles or ridges, over which the water flows in a thin sheet and thus exposes a large surface to the air. This type has the advantage of a low head loss but requires a comparatively large area. Some plants use a series of steps so arranged that the water has a free fall of about a foot between steps. This type requires more head than the riffles, but less area and in general will effect better aeration due possibly to the splashing of falls on the succeeding steps. Multiple splash trays are an elaboration of the series of steps. They consist of a number of shallow pans so arranged at levels one below another that the water overflowing the rims of pans on one level is caught on the pans of the next level below. This type secures the benefits of both the thin sheet of the riffles and the free fall and splash of the steps and is more economical of area than either.

Falls of one type or another are employed for aeration at Champaign, Ill., Excelsior Springs, Mo., Garretsville, O., Liberty, Mo., Red Bank, N. J., Sioux Falls, S. D., and Superior, Wis.

Contact trays are commonly built as a series of trays mounted one above another and filled with coke to depths ranging from 3 to 12 inches. The water is piped to the uppermost tray and then trickles downward through the coke and drops through slots or perforated openings in the supporting tray to the next lower one. They accomplish aeration by causing the water to spread out over the surface of the material and absorb air which may freely pass through the shallow depth of material.

Contact trays are employed for aeration at Liberty, Mo., Lodi, O., Memphis, Tenn., Shelby, O., Wausau, Wis., and Xenia, O.

Coagulation

In certain cases, the iron, after aeration, seems to exist to a large degree in an extremely finely divided or colloidal state, such that it is very difficult to settle. In such cases, the sedimentation is materially improved by treating the water with some form of coagulant. The agents ordinarily used for this purpose are lime, which also serves to remove the carbon dioxide, or a finely divided clay which seems to benefit sedimentation by a sort of mechanical coagulation. Ordinarily in the middle western states the iron precipitates readily

following simple aeration, so that the use of a coagulant is not necessary. The treatment of the water with lime is sometimes used, however, for the removal of carbon dioxide.

Sedimentation

The separation of a large part of the insoluble iron carbonate resulting from the process of aeration is ordinarily practicable by allowing the water to flow slowly and quietly through basins of ample capacity. In waters containing much organic matter the use of a coagulant is necessary. A detention period of about six hours is usually sufficient to settle out the bulk of the iron sludge. The amount that will not precipitate within this length of time can be more economically removed by filtration.

When used following contact beds, sedimentation performs an important service in catching and settling out the sludge which occasionally sloughs off from the contact medium.

Filtration

The process of filtration as applied for the removal of iron provides means for the deposition of the insoluble iron upon surfaces so arranged that they may be cleaned at intervals as necessary. Two principal forms have been employed, contact beds and sand filters.

Contact beds are intended to supply a large surface area over which the water passes and upon which it deposits the insoluble iron particles. Where sufficient aeration is otherwise provided, these beds are not primarily designed to aerate the water. Under some conditions, they are operated submerged with water, a condition that precludes aeration from the atmosphere. In various plants, they serve both functons of aeration and deposition by contact in various relative degrees.

A variety of designs have resulted from the various uses of contact beds. The flow may be either downward or upward. The downward flow bed provides opportunity for aeration, controlled by partial submergence if desired. Upward flow beds must always operate submerged. The contact medium is usually coke but a great variety of materials such as shavings, wooden slats, bricks, and broken stone have been used with success. Provision must be made for flushing out the accumulated iron deposits at intervals. With some contact media, a positive washing arrangement must be provided.

The use of contact beds as a final treatment process is not always satisfactory. With high initial iron content the amount removed is usually high, but this process may leave too great an amount remaining in the effluent. In such cases, they are commonly operated as prefilters, followed by sedimentation and sand filters.

Contact beds are used at Amesbury, Mass., Brookline, Mass., Griffin, Ga., Leroy, O., Lowell, Mass., and Middleboro, Mass.

Sand filters, insofar as their service for the removal of iron is concerned, are simple strainers exposing large contact surfaces to the water. For such purposes alone, they usually remove iron more thoroughly than contact beds. But, in addition to the service in iron removal, the filtration process yields such important benefits in clarification and bacterial removal, that its use is warranted even at the somewhat greater first cost. Sand filters are more easily controlled and less subject to periods of inefficient operation than the contact beds. In general, the design of filters for iron removal is not greatly different from those for other purposes of water purification.

Plants of the following places employ rapid sand filters as a final iron removal process: Benton Harbor, Mich., Champaign, Ill., Freeport, Ill., Griffin, Ga., Iowa City, Ia., Leroy, O., Marshalltown, Ia., Memphis, Tenn., Red Bank, N. J., Selma, Ala., Shelby, O., Sioux Falls, S. D., Wadsworth, O., Wausau, Wis. The plant now under construction at LaPorte, Ind., will use rapid sand filters.

THE EFFICIENCY OF IRON REMOVAL PLANTS

A number of iron removal plants in the middle western states treating water generally similar to that from the ground water sources of Indiana are shown in table 2. The treatment processes employed are indicated and the iron content of both the raw water and final effluent are stated as reported by designing engineers or plant operators.

These data indicate that modern well-designed plants employing aeration, sedimentation or prefiltration and final filtration will reduce the iron naturally present in ground waters to amounts that cause no objection. Some of the data given resulted from experimental studies or early operation periods of new plants and it is probable that even better results have been obtained with these plants after they have become well regulated.

TABLE 2

Reported efficiencies of certain iron removal plants in the Middle West

LOCATION	TREATMENT PROCESSES*	TOTAL IRON Raw	TOTAL IRON Treated	REFERENCE
		p.p.m.	*p.p.m.*	
Benton Harbor, Mich.	C S F	1.0–2.0	0.1†	(1)
Champaign, Ill.	A F	Practically complete removal		(2)
Leroy, O.	A P F	2.0	0.00	(3)
Memphis, Tenn	A P F	0.60–0.75	0.03	(4)
Shelby, O.	A S F	1.6	0.10	(3)
Sioux Falls, S. D.	A S F	4.0–5.0	0.15	(5)
Wadsworth, O.	A S F	1.4	0.00	(3)
Xenia, O.	A S F	1.4	0.10	(3)

* A, aerators; P, contact beds as prefilters; C, coagulant; S, settling basin; F, sand filters.

† Experimental result.

TABLE 3

Approximate investments required for iron removal plants

LOCATION	TREATMENT PROCESSES*	NOMINAL CAPACITY	INVESTMENT IN PLANT	INVESTMENT PER MILLION GALLONS PER DAY	REFERENCE
		m.g.d.‖			
Benton Harbor, Mich.	C S F†	2.0	$199,134	$99,567	(6)
Selma, Ala.	A S F	1.5	65,000	43,333	(7)
Shelby, O.	A S F	1.0	35,000	35,000	(8)
Sioux Falls, S. D.	A S F‡	8.0	89,000	11,125	(5)
Wausau, Wis.	A C S F	3.0	125,000	41,667	(9)
La Porte, Ind.	A S C S F§	4.0	124,000	31,000	

* A, aerators; P, contact beds as prefilters; C, coagulant; S, settling basin; F, sand filters.

† Includes additional processes for softening which materially increase cost.

‡ Existing filtered water reservoir utilized as substructure.

§ Existing settling basins utilized, but full capacity not required for iron removal.

‖ m.g.d.—million gallons per day.

THE COST OF IRON REMOVAL

It is not possible to determine easily either the average investment cost or the average operating cost of iron removal plants. Variable conditions materially affect the design of plants and the cost of their

construction. In many cases, existing works are utilized with considerable saving in new investment.

Table 3 gives a general idea of the investment usually required for iron removal plants. The data are as reported in currect literature. Full details of the structures and equipment covered by these are not stated in all cases.

In all of these plants the filtration is provided by rapid sand filters of modern design which, in addition to their functions in the removal of iron, also clarify the water and eliminate bacterial pollution.

These data indicate that complete iron removal plants, employing the processes of aeration, sedimentation and filtration, and chemical treatment if necessary, will cost from $35,000 to $45,000 per million gallons per day of nominal capacity. Substantial reductions from these figures may often be secured where it is possible to utilize existing basins and structures to advantage.

While the selection of the most efficient means and the detailed design of plant structures cannot be foretold without a study of the water, there is nothing to indicate that the iron in any of the ground waters of Indiana will not yield to treatment by the processes commonly employed or that the efficiencies of removal will be any less than are practicable elsewhere. Plants properly designed for iron removal will eliminate substantially all of the iron and in addition may be made to serve, with little if any additional expense, to remove turbidity, color, bacteria and hardness.

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(8) "The Removal of Iron from the Public Water Supply of Shelby, Ohio," by Philip Burgess, American City, 30, 5, p. 468.

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PITOMETER SURVEYS[1]

By Cyrus R. Bird[2]

In 1897 Edward S. Cole developed the pitometer and this instrument has come into very general use in this country. The pitometer employs the pitot principle. Two tubes enclosed in a metal sheath are introduced into a water main through a 1-inch corporation cock. Orifices are attached at the lower ends of the tubes, one facing upstream and the other downstream. The upper ends of the tubes are connected by rubber tubing to a glass U-tube partly filled with a colored liquid of specific gravity greater than water. The difference in pressure upon the upstream and downstream orifices occasioned by the velocity in the main, sets up a deflection in the U-tube from which the flow is computed. By means of the photo recording pitometer a continuous record of the U-tube fluctuations may be obtained.

The term "Pitometer Surveys" covers a field broadly classified, as follows: (1) water waste surveys, (2) trunk main surveys, and (3) re-design of distribution systems.

I shall discuss these in the order named.

WATER WASTE SURVEYS

The subject of water waste detection and prevention is not a new one. A recent translation by Clemens Herschel tells us that the early Roman engineers conducted a water waste survey of the Julian Aqueduct which was constructed between 313 B.C. and 50 A.D. as a result of which the available supply of water was almost doubled.

The purpose of a water waste survey is to account satisfactorily for the water supplied daily to the distribution system. The necessity or desirability of such a survey may be considered for several angles. If the services are 100 per cent metered, a check may easily be made to determine the unaccounted for water. A fully metered

[1] Presented before the San Francisco Convention, June 13, 1928.

[2] The Pitometer Company, New York, N. Y.

city should account for at least 85 per cent of the output. It is not impossible to account in some cases for as much as 95 per cent.

If the city is unmetered, a study of the night rate of consumption between the hours of 1 and 4 a.m. should be made. Allowing for any abnormal manufacturing use during the night, the minimum hourly consumption should not exceed 50 per cent of the average hourly rate, and it is often possible to reduce it to less than 40 per cent.

The amount of recoverable waste naturally varies widely in accordance with local conditions. The quantity seldom falls below 10 and in some instances has been found as great as 50 per cent.

A water waste survey starts at the source of supply. If this is by gravity, simultaneous measurements are made on the transmission lines to determine what loss, if any, occurs between the reservoirs and the distribution system.

Where the supply is pumped the survey starts at the pumping station and tests are conducted to determine the slippage of the pumping units. Where station meters are in service, tests are then made to determine the accuracy of these meters.

A forty-eight-hour measurement is then made of the total daily consumption. To ascertain the distribution of the consumption, the distribution system is divided into districts, usually aggregating from 8 to 10 miles of main per district. Each district, in turn, is isolated by closing the valves about its boundaries, excepting one, which is left open to supply the district during test. Upon the open main the recording pitometer is installed and a twenty-four-hour measurement of the flow obtained. Care must be taken in the selection of the supply main, for it must be large enough to supply the normal demand of the district and of ample capacity to provide fire protection. Coincident with the district measurement, the large industrial meters, if any, within the district are read. As the pitometer provides a continuous record of the rate of flow, a comparison may readily be made between the minimum night rate of consumption and the average rate. If this ratio is excessive, further investigation of the district is warranted to determine the cause.

The next step in the investigation is to determine the distribution of the night flow over the district. For the night subdivision of the district, the same boundary valves are closed, but a smaller supply main is chosen in order to obtain a greater velocity at the gauging point and consequently a greater deflection in the U-tube. The

district is gradually reduced in size by a process of elimination. Supply to the various blocks in turn is stopped by the closing of valves within the district. An outside valve is then opened so that service to the eliminated block is immediately restored, but no longer measured at the instrument. As the elimination process goes on, the successive decreases in rate of flow are registered on the pitometer photo record. Notes are kept of the time of operation of each valve and by plotting a time scale on the pitometer record the rate of flow in the various blocks is determined. In industrial districts, the large meters are observed for rate of registration at the time the blocks involved are shut off.

The blocks upon which unaccounted-for high rates of flow are found are then investigated. Valves, hydrants, service connections are sounded for indications. It is frequently necessary to drive bars to obtain contact with the main to locate a leak definitely. The wireless leak locator and geophone are sometimes employed. The leak having been definitely located, it is then uncovered and necessary repairs are made.

Engineers engaged continuously in this line of work become very proficient in locating underground leaks. To illustrate this: the water waste survey covering the entire city of Boston was completed about six years ago. During the course of this survey, 298 underground leaks of the mains and services not appearing on the surface were located, and in only three instances was it necessary to cut the city pavements, except at the point where the water was wasted.

Another interesting example occurred in Elmira, N. Y. Because of the construction of a new bridge over the river, an old street had been brought up to grade causing a 16-foot fill over the water main. A joint had blown and the water was escaping into the river; this leak was located by driving bars and using a geophone, although in no case were the bars in contact with the main.

In unmetered cities, the block by block subdivision affords valuable information for the control of house waste. The wasteful sections are definitely located and a minimum number of meters may then be installed with maximum effect.

Test for accuracy of registration is then made on all meters larger than 3 inches in diameter. These tests are made in place, the pitometer being installed immediately ahead of the meter. It is highly desirable to make such tests, especially upon current type meters, for, as the supplement to the American Water Works Association

Manual points out, the accuracy of such meters is affected by the nature of the installation.

Tests upon large industrial consumers are conducted for the purpose of detecting the unauthorized use of water. Many instances of such consumption have been found. In some instances, by-passes have been found around large meters. Often connections are found on unmetered fire lines and industrial supplies obtained in this irregular manner.

Examples

The case of the American Sugar Refining Company, of Brooklyn, N. Y., is a matter of public record. An ambitious superintendent had by-passed a 10-inch meter and was taking in this manner from the city, approximately 10,000,000 gallons of water a day. The matter was brought into the courts and argued for about nine years, when a verdict was brought in against the Company and they were forced to pay the city for the water which had been illegally used.

In many cases water is taken illegally by the city's industrial plants without the knowledge of the owners that such is the case. An example of this occurred in the small town of Northampton, Mass., where the workmen in the Mt. Tom Sulphite Company had to fill a tank twice a day. The Company had its own pump supply from the river under a pressure of about 30 pounds. They also had a fire connection to city mains under a pressure of 90 pounds. The workmen discovered that they could fill the tanks much more quickly from the city's lines and to do this were taking about $1,200 worth of water from the city every quarter.

In Newark, Ohio, one consumer was taking 900,000 gallons of water per day through an 8-inch connection on an unmetered fire line, without revenue to the city. It was found that this condition had existed for several years. Suit was instituted by the city and collection made.

During the course of the survey of the City of Boston it was dis covered that a 4-inch meter had been placed beyond a branch from the service line which connected to the street main. This was probably a mistake on the part of the employes of the water department and was unknown to the officials of the company. However, they were receiving free of charge about $10,000 worth of water annually.

Where local conditions make it desirable, special tests are made to determine output of wells; inflow and outflow from reservoirs to determine leakage etc.

In addition to determining sources of waste and loss of revenue, the survey provides further information on the condition of the system generally. As most of the valves in the distribution system are operated and tested during the course of the survey, a report of all defective valves is included. A like report is made of defective fire hydrants found.

Errors in the map of the distribution system are noted. Often mains are found not connected at intersections where they were supposedly connected. Valve locations are often in error, valves being found at unrecorded points and not existing at points shown on the map.

Incentives for survey

Incentives for conducting a water waste survey may be briefly stated:

1. To reduce the cost of operation. Buffalo, N. Y., reduced coal consumption 12,000 tons per year.

2. To increase revenues through testing large meters and checking large consumers for unauthorized use.

3. To increase the life of the existing plant and to defer the necessity of immediately extending the trunk main system. By reducing consumption to a minimum Syracuse, N. Y., deferred for approximately ten years the construction of an additional 30-inch supply main 21 miles long.

4. To increase fire protection through the elimination of waste and the check-ups on valves. One city of 30,000 population was found to have a closed valve on the principal main feeder. Poor pressure in half of the city had been experienced for several years When the valve had been opened, all complaints stopped. In another city of 50,000 population, approximately 16 important valves in the congested valve district were found closed.

5. The importance of locating leaks prior to cave-in of the street should not be overlooked. Many instances are found of serious undermining of streets. In one instance it was found that a leak, of which there was no surface indication, had started to undermine a bridge abutment.

TRUNK MAIN SURVEYS

The term "Trunk Main Survey" is intended to cover a complete investigation of the trunk mains of a water works system, to learn

what each main is doing under operating conditions, and to ascertain the friction coefficient.

There are two distinct phases to this survey and each is covered by separate operations. In the first place it is desired to know the flow under normal conditions from the source of supply and how this flow is distributed through the twenty-four hours. The most important point in this connection is the observation of the maximum rate of flow and the time of day when it occurs, as this, of course, has the greatest effect on the possible carrying capacity of the mains.

Measurements are carried on over the trunk main system with gaugings at all important connections, so that if any discrepancy is observed between the two ends of a section under test, the consumption along the line is measured; or if there are no intermediate connections, investigation for leakage can be made. Measurements on each section are made as nearly simultaneously as possible, although in some cases the total number of measurements necessary to cover a given section may be so great that only the principal ones can be made at the same time, the less important being made under similar operating conditions as soon as possible thereafter.

A study of the flows obtained in these measurements shows which mains are overloaded, or which may easily be overloaded by extra drafts on the system; and also those which are not under operating conditions justifying their existence. In one city where this survey was carried on it was found that a 48-inch main which had been constructed to relieve two 40-inch mains was carrying very little water, while the original mains were carrying a heavy load. An investigation showed that by adding a comparatively short stretch of 30-inch main the 48-inch would perform its work and take the over load from the other two conduits.

In another case a long length of 30-inch pipe had been designed to give adequate fire protection to a certain point at the far end of a 30-inch loop. The trunk main investigations showed that the point where the water was needed was at the center of the city which was inadequately fed, thus drawing the water around the 30-inch loop instead of by a more direct route from the pumping station. This proposed 30-inch main would, therefore, not be so efficient for the purpose intended as a considerably shorter line to the point where the water was needed at the center of the city.

The second phase of a trunk main survey is the determination of the value of the coefficient c in Williams and Hazen's formula. It is

not expected that extreme accuracy, such as might be obtained by laboratory methods, will be attained in these loss of head tests. Mechanical limitations of the instruments and other unavoidable inaccuracies will at times under certain conditions cause serious errors, but since these conditions never occur in tests where reasonable velocities and lengths of main are available, it will be obvious that such inaccurate results are of little moment, since the velocity must be so low that the load may be greatly increased without sufficient loss of head to interfere with the supply through that main.

The loss of head tests indicate three important points:

1. The comparison of the coefficient with the Williams and Hazen's tables indicates whether the pipe is deteriorating at about the rate that might be expected. This comparison gives a good idea of the internal condition of the pipe, and may be used in making up a program of pipe cleaning.

2. The presence of obstructions and partially closed valves is indicated.

3. The determination of the coefficients of existing pipe is very valuable in planning new mains, since it is readily seen how the pipe deteriorates under the particular conditions of a given water.

The fundamental aim of the trunk main survey, therefore, is to provide the water department with complete data for study of future requirements of supply.

In cases of smaller cities, it is unusual to find a trunk main system distinct from the distribution feeders.

For the flow measurements in a trunk main survey, pitometers are used, taps being placed at critical points on the main and at important connections. Twenty-four-hour measurements give the total, maximum and minimum flows, with the time of occurrence of the maximum.

For the loss of head tests specially calibrated recording pressure gauges are employed having sufficient interval in the chart spacing to allow accurate readings. Frequent checking of the calibration of these instruments is made to insure their accuracy. In making loss of head tests the gauges are installed with a pitometer at the two ends of the main under test and are kept in operation long enough to get a satisfactory determination of the head. During the test all side gates are closed, and care is taken that no large consumption of water occurs between the gauging points. Elevations are transferred to the gauges from city bench marks. From the data

obtained the coefficient is computed by the use of the Hazen-Williams hydraulic slide rule.

In order to have the data in convenient form, it is recorded on a large scale map of the trunk main system. The mains are drawn in lines of various widths to indicate their respective sizes and at each gauging point an arrow indicates the direction of flow. Beside this point the total, maximum and minimum flows and the maximum velocity are recorded. It is obvious that this arrangement is very clear and convenient for use in designing improvements.

A study of the map will usually indicate that even under present conditions certain connections and crossovers may be of considerable value, to force the system to operate as a unit and also to give proper supplies under emergency conditions, such as the shutting down of certain mains.

The complete data are of great value since they contain not only the information above, but also water level elevations—i.e., the head added to the elevation of the ground,—as well as the head at the gauging point itself. This may be used for studies of boundaries where the system operates under two or more pressure services. The charts of flow are also of value for studies of the use of water in various sections during any part of the day.

RE-DESIGN OF DISTRIBUTION SYSTEMS

The purpose of a distribution study is to provide a comprehensive plan for reinforcing an existing distribution system to meet adequately present needs and future requirements over a stated period of years.

For economy the construction work is divided into a program covering a number of years so that new work will not be done until necessary, thus saving interest charges on the investment; and also, as far as possible, to foresee developments, the needed mains should be installed by the time they are necessary. It is not possible in either case to lay down an inflexible program, since the state of finances, and especially the paving and re-paving programs will control in many instances.

The studies start with an investigation of the past and present population figures, from which must be made an estimate of the future population at the end of the period for which the program is to be prepared. The decennial census figures of the government are the basis for this estimate, supplemented wherever possible by the state censuses, as well as any local enumerations available. In

addition to the figures for the whole city, population by wards is of value in laying out mains to certain sections.

The consumption of water is measured by the pitometer into the various sections of the city and estimates of per capita consumption with the population figures for the future give a fairly approximate normal consumption rate for future design.

To this must be added the fire requirements. To determine the actual available supply, hydrant fire flow tests are made in various parts of the city. In addition, measurements of flow are made of individual hydrants where there is any question of an inadequate supply. A pressure survey is also made by taking hydrant pressures throughout the system on enough hydrants to give a full view of pressure conditions. Any points where an unexplained drop in pressure is found are investigated to find the reason therefore.

The trunk main capacities are studied by the fire flow tests mentioned above, and also by loss of head tests under normal conditions.

With these data in hand design of required replacements and new mains begins. This work is divided into two parts, the needs for the present to bring the system up to its proper capacity, and the future needs covering the period for which design is being made.

This leads directly to the program of construction, since all designs are made with the time of their necessity in view. It is usual to find that there are a number of relatively expensive improvements needed in the near future; and the result is that the expenditure for the first few years of the period must be rather higher than in the later portion. At the same time there will be many replacements of small pipes by larger ones which in some instances may be deferred until the more important work is out of the way. The effort is made to make the expenditures over each five-year period somewhat nearly equal and each recommendation is carefully considered, both as to the time when it will be needed and as to the equalization of cost over the time divisions.

It is not contemplated that finished designs will be furnished in this kind of a survey, therefore, the specifications for pipe and specials, as well as valves and hydrants, are not given in full, since they should be the same as those of the American Water Works Association at the time of purchase. Any special materials recommended for early use are specified completely.

The need for such a program is obvious. In almost any city instances may be found where, in some previous administration, the

powers that be had made up a tentative program along which they had started to construct without placing the entire design on file. The result is that large mains leading nowhere are found, such as a 30-inch main in a New England city which was built a number of years ago under such conditions, and which has never been made use of because the territory towards which it was headed never required so much capacity. It is doubtful if it ever will grow to need it.

In one large city recently a 20-inch main was laid in advance of new paving to connect with a 36-inch. A complete program of future construction would undoubtedly have indicated a larger main to maintain the integrity of the 36-inch main to the point of connection with the new supply conduit entering the system south of this section.

Pitometer surveys are significant of the present day progress in water works design, efficiency and operation, as well as in every other line of endeavor. In years gone by municipal water systems were designed and operated as efficiently as possible with the information at hand. This information, however, was inadequate, and the available data at best were only approximate.

However, by means of the investigations outlined in this paper, definite knowledge of the actual underground conditions may be secured so that a sound basis is obtained for operation and design.

THE USE OF THE FLUSHOMETER VALVE[1]

By W. H. Durbin[2]

The flushometer valve is not of recent origin, since it has been on the market for probably twenty-five or thirty years. However, some of the companies manufacturing this type of equipment have put on an aggressive advertising campaign during the past few years and this, together with a uniformly satisfactory record of service, has caused the demand to increase quite rapidly.

The flushometer valve to operate satisfactorily requires a flow of water of 30 gallons per minute with preferably a residual pressure of from 5 to 10 pounds to give the proper flushing action. It has been used largely up to the present time in schools, hotels, office buildings, etc., but only to a limited extent in the smaller commercial establishments and residences. In the case of schools, public buildings, hotels, and other types of consumers, where a relatively large quantity of water is used, we have no objections at Terre Haute to their installation and feel that they possibly have certain advantages over the old type of closets.

Should however the use of the flushometer valve be extended so that its installation in the smaller commercial establishments and residences is to become quite common, a very heavy expense will be placed upon the water utility in the way of providing increased service and meter capacity, if the premises are to be supplied without the use of a pressure or gravity tank or some auxiliary equipment. In this, I am assuming, as is the case at Terre Haute, that the water utility bears the entire cost of installing both the service and meter. The friction loss through a 1-inch meter when delivering water at the rate of 30 gallons per minute, will vary from 10 to 15 pounds, depending upon the style of meter used. This means therefore that, if the entire responsibility is placed upon the water utility to furnish connections that are ample in size and capacity for the operation of this fixture, not less than a 1-inch meter should be installed and preferably a $1\frac{1}{4}$-inch service line, although under some circumstances

[1] Presented before the Indiana Section meeting, March 16, 1928.

[2] Superintendent, Water Works, Terre Haute, Ind.

possibly a 1-inch service would suffice. A meter less than 1-inch in size has not the capacity to accommodate the heavy flow that is placed upon it and broken discs, thrust rollers and other damages are likely to occur. To place in motion a column of water which is stationary and increase this to a rate of 30 gallons per minute almost instantaneously means that the moving parts of the meter are subjected to a very heavy strain.

The water utility is dependent upon the use of water for its income and is willing to assume additional expense in the installation of its equipment providing there is to be additional revenue obtained. The more water used, the better, but to supply 99 per cent of the water in 1 per cent of the time is not fair to the utility. The argument that the demand for water is constantly increasing due to a greater number of fixtures being installed does not compensate for the maximum peak demand and this will govern in determining the size of the service and meter installation. Not only must the size of the service and meter be considered, but the street main as well. A great many consumers are now receiving first class service through a 2-inch main. If the flushometer type of a valve is to become quite common, it will mean that the 2-inch main can no longer be used.

The points usually emphasized in favor of the flushometer valve are that it requires less water and at the same time is less likely to get out of order than the flush ball type of closet. We are of the opinion that the saving in the use of water is probably over-exaggerated and that the customer will not be benefited to any great extent by its installation. As to its reliability we would welcome a piece of equipment that would be more positive and freer from the waste of water than the ordinary flush ball type of closet. However, it has been our observation in Terre Haute that the flushometer valve does at times get out of order and the waste of water is as pronounced as in the old flush ball type. Where the flushometer valve is not working properly, it is liable to cause a water hammer with the resulting possible damage to the meter, service connection and even the main in the street. Cases have been reported where the shock has been transmitted to plumbing fixtures installed in adjacent buildings, although it is hardly probable that this would occur very often.

Our rates provide a minimum charge in accordance with the size of meter installed. For the $\frac{5}{8}$-inch meter, the minimum charge is \$1.00 per month, while for a 1-inch meter, it is \$3.00 per month. The average domestic bill is considerably below the minimum for the

1-inch meter and this fact will tend to keep down the number of flushometer valves installed where connection is made direct without the use of a pressure or gravity tank. If the tank construction is used, very good service can be obtained through the ordinary $\frac{5}{8}$-inch meter. The objection to this type of construction is that the air cushion in the top of the tank will escape and it is necessary to replace this at more or less frequent intervals.

CHLORINATION OF PIPE LINES UNDER CONSTRUCTION[1]

By John R. McClintock[2]

We, who have been engaged in construction for several years, can, no doubt, recall the days, when about all the special care that was taken of pipe lines under construction, was to inspect pipe and fittings for defects, "swab them out," that no rocks, sticks or other debris, might be left therein and place them in the ditch. But time has moved on, and as large towns and great cities are being built up, people have of necessity found that they must leave the family well and town pump for a more adequate and wholesome water supply.

To produce a perfectly safe water supply, it is not only imperative that the utmost care be taken at its source of supply and all the way through the different stages of treatment, such as sedimentation, filtration and chlorination, but also to see to it that nothing of a contaminating nature reaches that supply until it is delivered to the consumer. To this end it has been found that great care must be taken in making new additions to the pipe or distribution system.

Let us assume that a car or train load of pipe begins to receive its supply of dust, cinders and whatever else it may pick up, in course of shipment from the foundry to point of delivery. Add to that the fact that most pipe, after railroad delivery, is hauled directly to the job on which it is to be used and there distributed along the side of the street to await the arrival of the construction gang, whose work it is to place it. This may be a matter of days or it may sometimes be weeks. During this period the pipe has not only received its supply of shipping dust, but also an accumulation of street dust and sediment produced by water flowing through it in time of rain storms and other sources. All sorts of debris are thrown in by playful children. All these things combine to produce a condition that is sometimes very unsanitary.

To overcome all this, as far as possible, the company for whom I work, has for sometime required its construction foreman to see that the pipe is not only well "swabbed" and made thoroughly free of any

[1] Presented before the Indiana Section meeting, February 27, 1929.

[2] Construction Foreman, Indianapolis Water Company, Indianapolis, Ind.

loose matter before placing it in the trench, but also that it is well chlorinated after being placed therein.

The process by which this is done is very simple and does not require a great amount of time. It is as follows:

Make the "first end" connection and as first length of new pipe is laid or connected to existing main, one can or container of hypochlorite of lime should be shaken into that length of pipe and at each interval of eight lengths of pipe another container should be emptied into that length of pipe and so on to the completion of line.

However, when a hydrant or a valve also is set in the main the valve may be closed and the line filled slowly from point of first connection until first appearance of water at hydrant, when the hydrant should be closed and the water allowed to stand for thirty minutes and then flushed thoroughly until no odor of chlorine can be detected in the waste water.

This facilitates the work of back-filling and flushing trenches by getting part of the new line into service. Water used to flush out pipes need not be wasted, for where economy in *amount of water used* is an item, it can be profitably used to flush or settle back-filled ditches.

On first thought it appears proper to make an allowance for the relative capacity of different sized mains, but we believe it more likely to be handled successfully if construction formen are instructed to place a given quantity at the head of each 100 feet of pipe laid and flush it out thoroughly when job is complete up to an end hydrant.

The reason for this is that for 36-inch pipe at a dose of 100 pounds per million gallons, the quantity required is 1 pound per 100 feet. In either case it is necessary to flush the line until no odor of chlorine is detected at discharge hydrants. The removal of chlorine from the line to this degree will insure thorough cleaning by displacement alone in addition to the sterilizing effect.

While the pipe line is incomplete all openings should at all times be kept plugged, which will prevent circulation of air and thus preserve the strength of chlorine until its final removal from the pipe. After completion of the pipe line care should be taken to see that, in the removal of this treatment, none should be allowed to enter any existing line.

To get the best results it has been our method to open a fire hydrant at the furthest end of line, then to open a valve at point of beginning, letting water flow through the pipe slowly until it appears at the

hydrant, shut it off for period of about thirty minutes, then open up and blow out thoroughly until the water shows clear.

At this point, reverse the operation by closing the valve and hydrant first opened and then open the valve and hydrants at opposite end of line and blow out until water is clear and free of odor of chlorine, after which open all hydrants on the line, then proceed to turn on all intersecting lines beginning at end of line from which water is flowing, still keeping hydrants open to carry out any chlorine that may have lodged in ends of branch lines and lastly open up the valve on furthest end of line.

In case there is no hydrant on the end of the pipe line thus treated, it is necessary to shut off the adjoining section, opening up several hydrants first. Then open valve from new section, letting water blow out as speedily as possible that the line may be cleared of all effects of treatment before being taken into service lines of consumers.

This instruction to disinfect newly laid pipe lines should in no way, however, lead construction foremen to reduce the degree of care they have previously used in cleaning and flushing such lines.

As a matter of general information the chlorine container stocked by commercial dealers holds 12 ounces. A case of these contains fifty and costs $5.60.

In conclusion, let me emphasize the point that water used in flushing out treatment need not be all waste as it can be used to flush or settle backfilled ditches.

In case of a "dead end" where it is impossible to blow out the line, the only thing to do is to use extreme care that the pipe used therein be well "swabbed out" before being laid.

SHOULD METERS BE READ MONTHLY OR QUARTERLY?[1]

By W. H. Durbin[2]

Since April, 1925, it has been the practice at Terre Haute to render bills quarterly on practically all domestic and the small commercial accounts, while the larger commercial accounts and the industrials pay monthly.

The average number of live accounts during the year 1927 was 11,850, while the average number of bills rendered each month was 4,555. It will be seen therefore that the number of bills rendered each month is approximately 40 per cent of the total accounts. The rotary quarterly billing is followed, the city being divided into three sections with statements rendered on the first of each month.

The average meter reading cost for the year 1927 was 2.57 cents. This expense included all rereads, transportation and other incidentals. Where a customer is billed quarterly, every effort is made to obtain the meter statement. If this is not possible after two or three attempts have been made, an estimated bill is then rendered, based upon the customer's past record. It is estimated that the quarterly billing reduces the expense of reading meters to the extent of approximately \$190.00 per month and the elimination of at least one and possibly two clerks in the office.

It has been our observation that the people are as a rule favorable to the quarterly billing and prefer this to the monthly statements. The average quarterly domestic bill for the year 1927 at Terre Haute was \$3.85, while the minimum charge, based upon a $\frac{5}{8}$-inch meter, is \$3.00, and this entitles the customer to the use of 8,250 gallons of water.

The only time that serious objections are raised to the quarterly billing is in the case of a leak. The soil at Terre Haute is largely sand and gravel. As a consequence, an underground leak of considerable magnitude may occur before showing upon the surface. Where a considerable loss takes place between the curb and the basement that is unknown to the customer, we feel that the customer should be

[1] Presented before the Indiana Section meeting, March 16, 1928.

[2] Superintendent, Water Works, Terre Haute, Ind.

given some consideration in the way of an adjustment and this practice is followed. However, with the monthly billing it was often necessary to follow the same practice and as a rule the complaint is no harder to handle under the quarterly than under the monthly billing.

It cannot be denied that the possibility of loss is greater under the quarterly than under the monthly billing, and this is where the utility will suffer unless proper precautions are taken to protect its interests. From our experience this can best be accomplished through either an advance payment or a meter deposit; a personal guarantee not being satisfactory. As the rules at Terre Haute do not provide for an advance payment, a meter deposit is required not only from tenants but property owners as well. We have never been able to make collection of an account past due on the basis that the charge was a lien against the property. If the party making application is well established in the community, or has a past record of prompt payment the deposit is waived whether owner or tenant. A deposit is required on all new accounts where the water company must spend from $25.00 to $40.00 for the installation of a new service and meter.

At the present time, approximately one-third of our consumers have made deposits with the company, the minimum being $5.00. Interest is allowed at the rate of 4 per cent per annum where the money remains with the company for six months or more.

The company reserves the right at all times to change an account from quarterly to monthly or vice versa; also to increase the amount of the deposit. If a quarterly account is running quite high and it is the feeling that payment is not very secure, rather than ask for an increase in the deposit, the account is changed to monthly.

During the year 1927, the amount written off as uncollectible was 0.2 per cent of the operating revenue. The 1927 figure is above the average, due to one of our large industrial plants going into the hands of a receiver and leaving a bill of $339.00 unpaid. We are now accruing a reserve for uncollectible accounts that is equal to approximately 0.12 per cent of the operating revenue. From present indications this amount is going to more than meet our losses.

From a business standpoint, it is better for the customer to make a deposit than to pay a minimum charge in advance, due to the fact that the deposit draws interest while the advance payment does not. However, the suggestion of a deposit is usually resented by the

customer and he at once thinks that his honesty is being questioned. It is an advantage to both the consumer and the water company to keep the uncollectible accounts to a minimum. Service cannot be rendered without cost and some one must pay. This fact is explained to the customer and if he wants to be fair he will see the justice of the meter deposit. We find that people are now far more receptive to the deposit idea than formerly. On the whole, we are of the opinion that the advantages more than offset the disadvantages of the quarterly billing.

THE ACTIVATED CARBONS AND THEIR USE IN REMOVING OBJECTIONABLE TASTES AND ODORS FROM WATER[1]

By John R. Baylis[2]

The ever increasing demand for things that give satisfaction is not confined to one line of endeavor. Most industries of any size now have one or more employees engaged on research work hoping to improve the quality of their product. Especially is this true for industries producing or handling things that we eat or drink. The demand for palatable drinking water keeps increasing as we progress along other lines, and it is now reaching the point where, it is believed, water works officials must begin looking for new methods of treatment that will produce more perfect water.

Industry after industry has been called upon to eliminate or render inoffensive its waste products discharged into a water course used for a public supply. In some instances this is producing a heavy burden upon the very industries that give employment to the inhabitants of the cities and villages whose water is being polluted. With the elimination or purification of much of the wastes from industries, the increasing population still causes so much pollution that present methods of treatment are taxed to their limit to produce a fair quality of water in some localities. The margin of safety against taste becomes narrower and narrower for some of our supplies, now producing satisfactory water. The time is not far distant when steps must be taken to obtain a less polluted supply or there must be an improvement in purification methods.

Is it not time that we make a bold step towards safety from objectionable tastes and odors just as a bold step was made years ago against water-borne diseases when filtration and chlorination were introduced and the water in many of our cities was made tolerable? Believing that something of this nature is vital to the future of water treatment if we expect to keep palatable many of our water supplies, the writer offers this discussion on the possibilities of using the activated carbons in water treatment.

[1] To be presented before the Toronto Convention, June 27, 1929.

[2] Department of Public Works, Chicago, Ill.

ACTIVATED CARBON IN INDUSTRY

The extensive use of bone char and other active carbons in the sugar industry for removing color, and their use as one of the adsorbing materials in gas masks, give us an abundance of information on the characteristics of such materials. The active carbons, however, have been used so little in water purification that not much is known regarding them from actual experience. It is true that bone char, and perhaps some of the vegetable chars, have been used to a limited extent in household or other small filters for a number of years. The writer is not aware, however, of much published data as to the benefits derived.

It has been known for many years that charcoal has remarkable adsorptive powers. Strachan (1) says it seems to have been known that it could be used for removing coloring matter from solutions in the fifteenth century. He also states that, according to Lippman, wood char was utilized about 1794 in an English refinery for purifying sugar solutions. Peter and John Martineau patented in England the use of bone char in 1815, and this kept the use of vegetable chars in the background for many years. In fact it was not until gas masks were required in the World War that vegetable carbons came into extensive use. Mantell (2) states that:

> By agreement the credit for the introduction of animal charcoal into the sugar industry is usually given to Derosne, who started its use in 1812. . . . . The suggestion that bone char could be regenerated and used over again was made by Dumont and Schatten.

Mantell also gives a list of 19 vapors and gases that Hunter, in several articles published from 1863 to 1872, showed were adsorbed by charcoal to a marked extent. Hunter's experiments covered more ground than that of any one else at the time. The use of poison gases during the World War brought back into use the vegetable chars, largely because they had greater adsorptive capacity than bone char. It also started a vast amount of research work on the adsorptive powers of the active carbons and methods for producing the most active materials. The work of Chaney, Ray and St. John (3) on the preparation of active carbons, and Miller and his co-workers (4) on the characteristics of the active carbons, has done much to extend their use into various fields of gas adsorption and adsorption from solution.

BONE BLACK

This is the carbonaceous residue obtained by destructive distillation of fresh, hard bones free from extraneous matter. The mineral constituents of the bones suffer little or no change by the heating. The main constituent of bone char is tri-calcium phosphate, which averages about 75 per cent of the weight. Only about 10 per cent of the material is carbon. There has been much discussion as to the manner in which bone char performs its work. Horton and his colleagues (5) have shown definitely that bone black owes its power of removing color to the presence of active carbon, and that the nitrogenous material serves as a reserve to supply fresh carbon upon re-ignition. One reason that bone char has been used so extensively is that it is hard and there is not much loss in handling. It has been used to a limited extent in household and other small filters.

VEGETABLE CHAR

Almost any vegetable substance can be converted into decolorizing and adsorptive char. Mantell (p. 192) mentions pine, birch, logwood, quebracho, hemlock, cedar and other woods, corn husks, cobs, corn stalks, cane trash, bagasse, peat, coals of various kinds, lignite, rice hulls, molasses, alcohol slop, waste liquors and extracts resulting from paper manufacture, ivory nut shavings, cocoanut shells, peach nut shells and various fruit kernels, olive oil and other vegetable oil residues and pits, etc. It is not so much a question of the type of material, but the physical properties of the char produced. For most filtering purposes it is more desirable to pass the solution through a bed of granular material than to add the powdered char to the solution, which later has to be filtered out. The problem of making a hard dense char from vegetable products is not so simple. The vegetable chars are usually subjected to some special treatment to make them more applicable for practical uses. Mantell divides the vegetable chars into three classes, according to their method of manufacture.

1. Carbon may be deposited on a porous inorganic base, such as infusorial earth, pumice stone, insoluble salts and other materials. The mixture of carbonizable vegetable material and the inorganic base is strongly heated to deposit the carbon on the base.

2. Carbon may be deposited on an inorganic base which is afterwards separated from the carbon by chemical means. Such substances as lime, chalk, sulfuric acid, calcium chloride, zinc chloride,

magnesium chloride, phosphoric acid, etc., may be used. The commercial carbon termed carboraffin is made by the employment of zinc chloride as the activating material. Porous wood may be treated with lime or calcium acetate, carbonized at nearly white heat under a layer of lime, cooled, given an acid treatment with hydrochloric acid and recarbonized at red heat with the air excluded. Other carbons made by the zinc chloride process are known as radit and antichromas.

3. Carbonizing materials such as lignite, waste pulp liquors, black ash residues, sawdust, woods and similar materials in retorts under controlled conditions of temperature and atmosphere. The greater amount of active carbon from vegetable compounds are being manufactured by this process.

Darco is made from lignite. The lignite is crushed to about 2 to 4 mesh and is then continuously conveyed to a horizontal rotating retort where it is destructively distilled at a very high temperature by means of external heat application. The heat treatment drives off the volatile matter and leaves the fixed carbon in an extremely porous condition. The carbon is cooled out of contact with the air, and receives further treatment in the way of regulation of particle size and removal of inorganic acid solubles to adapt it to specific uses. Nuchar is made from the paper mill waste liquors. Norite is made by the carbonization of birch wood and afterwards gas activated. Suchar is made somewhat similar to Nuchar. Carbox is made from rice hulls.

PHYSICAL PROPERTIES

A good carbon should have mechanical strength, be of the optimum density for its particular use, and have high activity. The materials possessing considerable mechanical strength, such as bone black and Minchar are low in carbon and do not have a great adsorptive capacity. As a rule, the nearer a material is 100 per cent carbon the less is its mechanical strength. Nuchar is usually over 95 per cent carbon, but so far its use has been confined almost exclusively to the powdered form for applying to solutions. In some processes this is all right, but for water purification the cost would probably be prohibitive.

Darco can now be manufactured with sufficient strength to be used in the granular form for filter beds. This material contains about 70 per cent carbon, the balance being largely silica. The writer has

been told that Minchar is largely aluminum silicate. Mantell (p. 158) says the best adsorbent carbons cannot be made directly from wood charcoals, and that with the exception of a few hard woods, of which the supply is negligible, the wood chars are too low in density even before activation. The low density wood charcoals have to be pulverized and briquetted to denser chars to make them compare with the dense nut chars.

For gas adsorption, there is a critical density or porosity that will give its maximum adsorptive capacity. A porosity of about 66 per cent is given by Chaney and his co-workers as the optimum density for individual granules. This gives an approximate density of 0.4 for 8 to 10 mesh granular carbon. Less porous material will have its adsorptive capacity per unit of weight of carbon reduced and more porous material will have a less adsorptive capacity per unit of volume. The volume probably is of no significance in water purification, except that the more porous materials are light, usually soft, and may not be suitable for filter beds. Lamb, Wilson and Chaney (6) estimate that 1 cc. of active gas mask charcoal has a surface of 1,000 square meters at the most effective density, 0.4. With such an enormous surface area it is evident there are many carbon atoms on the surface having 1 to 3 free valencies. Chaney believes that activated carbon is essentially a special form of amorphous carbon deposited at low temperature and free from adsorbed and stabilized hydrocarbons which are normally associated with it.

ACTIVATION

The activation of carbon requires careful heat control and is usually done in closed retorts. The activation must be done in the absence of hydrocarbons or other strongly adsorbed compounds. The hydrocarbons are recovered by a careful adjustment of the temperature and the concentration of oxidizing material. Air, steam, carbon dioxide and chlorine have been used for the oxidizing material. Steam activation seems to be regarded as being better than air. Most authors give a temperature of 900 to 950°C. as that which produces the most active carbon. This, however, depends somewhat on the ease with which the hydrocarbons are driven off. The hydrocarbons are slightly less resistant to oxidation than the active carbon.

ADSORPTION

Perhaps it is well to say just a few words on adsorption as this is the manner in which the soluble constituents of the water are removed by the carbons. Numerous articles in the chemical literature on adsorption eliminate the necessity of an elaborate explanation of how adsorption takes place. If a piece of blotting paper or other porous material is submerged in water there is a certain amount of water that will not run off when the porous material is removed from the solution. The retained water is usually referred to as being absorbed. So far as is known, none or only a very small amount of the water enters into combination or is actually adsorbed by the paper. With adsorption there is supposed to be some kind of a loose chemical combination with the surface molecules of the solid and the substance adsorbed.

Carbon, as we know, has a valency of 4 and every atom of carbon on the surface has at least one free valency. With the irregular shape of the amorphous particles some of the surface atoms may have two and occasionally three free valencies. These free valencies have the power of uniting with or at least attracting to their surface certain compounds that come in contact with or near them. There are several well-known formulae for the adsorption of materials from solutions. The adsorption of phenol by carbon appears to follow the Freundlich adsorption equation very closely.

REVIVIFICATION

In some instances the use of carbon would not be economical if it had to be discarded after it reaches a point where it will not produce the desired results. Bone char will clarify only about 1 pound of sugar per pound of char, and it is evident that such a material would not be economical if it had to be discarded with only one use. Bone char is usually revivified by kiln burning at about 750°F. It is then cooled out of contact with the air. Some attempts have been made to revivify the vegetable chars by heat treatment somewhat as for bone char. Various uses of the active carbons in the industries makes the revivification dependent largely upon what it has adsorbed. In some instances it may be desirable to treat with an acid or an alkali in addition to the heat treatment. Partial revivification may be obtained in some instances by passing steam through the bed of carbon, but this depends on what the material has adsorbed. The writer has attempted to revivify carbon that has adsorbed

phenol by the use of chlorine with some indication that it is at least partially revivified.

USES OF THE ACTIVATED CARBONS

The activated carbons are used already quite extensively in the industries. There are two general classifications for its use. One is the adsorption of gases and vapors, and the other is the adsorption of compounds from solutions. In the adsorption of gases, it is used in removing certain poisonous gases from air, and the abatement of stenches and odors; recovery of gas, solvents, etc.; purification of gases; catalysis of gas reactions; storage of compressed gases; and evacuation of vessels. Chaney, Ray and St. John give the following industrial applications for activated carbon in liquids:

1. Making white sugar directly from cane juice; ultimately it is used in part or whole in refineries.
2. Purification of both organic and inorganic acids, such as lactic, citric, acetic, tartaric, phosphoric, etc.
3. Purification of a great variety of organic liquids—alcohols, acetone, cane, maltose and glucose sirups, glycerol, etc.
4. Decolorization of waxes, gelatin, glue, etc.
5. Removal of objectionable colors and flavors from edible oils and fats.
6. Decolorizing and purifying petroleum oils.
7. Water-purifying filter, removing tastes, odors, and bacteria.
8. Recovery of rare metals such as gold from dilute solutions.
9. Recovery of alkaloids from solution.
10. Pharmaceutical and medical reagents and preparations.

With this list of possibilities, some of which are in practical use already, a number of objectionable compounds which may occur in water should be removed by active carbon. Certainly this material deserves careful investigation as to its possibilities.

EXPERIMENTS ON THE USE OF ACTIVATED CARBONS

Work on the use of activated carbons so far has been confined largely to the removal of phenolic compounds and to the dechlorination of water. None of the materials have been in use long enough at this writing to determine their useful life, or their limit in the removal of taste-producing compounds. That they will remove taste-producing compounds other than the phenolic compounds is evident, but they may not remove all such compounds that are likely to occur in water.

Removal of phenols

Adsorption of phenol from water by the active charcoals probably has been known for some time, but it was not until the publication of adsorption curves by Freundlich (7), in 1926, that the writer became aware of this fact. Not long afterwards (December, 1927) Chicago experienced in its water supply probably the greatest phenolic occurrence of any large city in the country. Damages, largely to food products, were estimated to be fully one-half million dollars. Food cooked with the water in perhaps 200,000 homes tasted so strongly of chlorophenol that it could not be consumed.

Efforts to prevent future occurrences naturally should be turned first to the possibility of elimination, but sometimes this cannot be accomplished as quickly and easily as one may wish. Especially is this true where part of the pollution comes from an adjoining state. Even where there has been elimination the water is not always free from taste, due largely to occasional mishaps in the eliminating process, or to incomplete elimination. With no intention of discouraging the excellent work done by the health authorities in a number of states in reducing pollution, the situation is not entirely satisfactory and probably will never be until the water works assume part of the burden and be prepared to take care of a reasonable amount of pollution. This does not mean that there should be a let-up in efforts to reduce pollution, but 100 per cent elimination may be more of a burden on a community than partial elimination by those producing the pollution and the balance to be taken care of in the filtration plants.

The Chicago phenol occurrence started efforts along two lines. The Department of Health has been trying to force elimination by the industries, and the Department of Public Works at its experimental filtration plant has been conducting experiments to see if it would be practical to treat the water so as to prevent tastes and odors.

Howard (8), at Toronto, has done excellent work on the prevention of chlorophenol tastes. When phenol is present, or is likely to be present, the water is super-chlorinated to the extent that there will be about 0.5 p.p.m. or more of residual chlorine. After about one and one-quarter hours it is dechlorinated with sulfur dioxide. McAmis (9) has tried adding small amounts of ammonia (approximately 0.25 p.p.m.) to prevent tastes that he assumes to be chlorophenol, although there is no known phenol pollution. He reports satisfactory taste elimination regardless of what may be the cause. The cost of the ammonia treatment is estimated to be approximately 60 cents per million gallons. Enslow (10) reports the permanganate-chlorine treatment

successful in preventing tastes at Rochester, N. Y., and the water supply owned by the Western New York Water Company at Buffalo, N. Y. He also reports that experiments at the Rensselaer, N. Y., filtration plant indicate this treatment to be successful in preventing taste. Credit for the first use of permanganate in America is given by Enslow to J. M. Caird for its use at Rochester. An average of 0.05 to 0.09 p.p.m. of $KMnO_4$ was used at Rochester and 0.03 to 0.04 p.p.m. at Buffalo. The cost of the permanganate treatment at Rochester has averaged about 15 cents per million gallons. The writer has been told that East Chicago ran some experiments with permanganate, but he has no information as to the results obtained.

Notwithstanding the apparently successful results of the several methods of preventing tastes where the water is treated with chlorine, the writer feels that there is much yet to be desired. The methods very likely produce a vast improvement over previous conditions and should be continued until something more effective is developed, but it is believed that these treatments should be regarded as temporary procedures pending the development of something better. The fact that no complaints are received does not mean that the water is entirely free from taste. In such experiments as we have conducted on super- and de-chlorination, there was an elimination of the chlorophenol taste, but the water did not taste up to standard. Any treatment that may be upset by a change in the character of the water requires the best of technical supervision. Even then mishaps will occur often enough to allow the occasional production of taste. This has been the history of all treatment processes requiring the continuous addition of one or more chemicals to the water, and especially is it true for the smaller plants. Very few plants have a chemist on duty twenty-four hours each day, and very few of the plants with capacities less than 4 million gallons daily have a chemist on duty at the plant every day.

It was with the hope of developing a treatment that would be less subject to failure to eliminate taste in case of mishap or the wrong application of chemicals that the writer started experiments on the use of activated carbon for removing or preventing tastes and odors. The work was started in June, 1928, and has been under way for nearly a year. Naturally our first experiments were on the removal of phenols, for it was the occasional presence of such compounds that caused the work to be undertaken as a part of our experimental program. Most of the work to date has been on a laboratory scale. One of the filters, however, in the experimental plant has been filled with 2 feet of Darco (one of the active carbons). The laboratory

filters have glass tubes about 1⅝ inches inside diameter and 5 feet long. They are so arranged that any desired rate of flow may be maintained. Plan of the filter has been shown in articles already published (11), though its use there described is confined to filtration with sand.

The first carbon laboratory filter was constructed with a bed of the granular material about 27 inches deep, being composed of equal volumes of Darco and bone char. The reason for the mixture was that we did not have enough of either material on hand at the time to fill the filter to the desired depth. The water was polluted with waste liquor from a by-product coke-oven plant, the ammonia still wastes being used. The phenol content of the liquor was determined and proportional amounts added to the Lake Michigan water to give the desired phenol concentration. In addition to the phenol there probably were other compounds present in the waste liquor that were removed by the carbon.

The filter was not run continuously, but when it was run the water was passed through at the rate of about 2 gallons per square foot per minute, this being the customary rating for rapid sand filters. The filter was run during the day only and was not run every day. At the rate given, about 50 liters would be passed through the filter in six and one-half hours. The results of the experiment are given in table 1. It will be noted that increasing amounts of phenol were added and that none, or only a trace, passed the bed until the amount was increased to 100 p.p.m. It also will be noted that it was not until 10 p.p.m. of phenol was being added that a faint taste was produced after the addition of chlorine, and even then the taste was so slight that we could not state definitely that it was a chlorophenol taste. The tests for phenol indicated that there was less than 0.001 p.p.m. of phenol present in the solution after passing the filter until the last day's run, the figure for which happened not to be recorded. All phenol tests were made by our modification of the Gibbs (12) method and should be fairly accurate. The adsorptive capacity of bone char for phenol is not very great and there is no doubt that more phenol was adsorbed by the Darco than the bone char.

Minchar has a low adsorptive capacity because it does not contain much carbon, yet it will remove considerable phenol. This is shown by table 2. Minchar is fairly hard and will stand much more handling than some of the materials having a high percentage of carbon. The filter was filled 24 inches with this material and it was operated

TABLE 1

Phenol adsorption by activated carbon

The bed contained about 130 grams of granular Darco and an equal volume (about 260 grams) of bone char.

DATE (1928–1929)	LITERS FILTERED	PHENOL ADDED	PHENOL IN EFFLUENT	TOTAL PHENOL ADSORBED	TASTE OF EFFLUENT AFTER ADDING 0.25 P.P.M. CHLORINE
		p.p.m.	*p.p.m.*	*grams*	
June 1	0	0.1	0.000		
June 12	300	0.1	0.000		None
June 18	500	0.1	0.000		
June 28	750	0.1	0.000		
July 12	1,000	0.1	0.000		
August 6	1,500	0.1	0.000		
August 16	1,800	0.1	0.000		None
August 23	2,000	0.1	0.000		None
September 14	2,400	0.1	0.000	0.24	None
September 27	2,700	0.2	0.000		None
October 1	2,800	0.2	0.000		None
October 4	2,900	0.2	0.000	0.34	None
October 8	3,000	0.4	0.000		None
October 15	3,100	0.4	0.000		None
October 19	3,200	0.4	0.000		None
October 23	3,350	0.4	0.000		None
October 24	3,400	0.4	0.000		None
October 25	3,450	0.4	0.000		None
October 31	3,600	0.4	0.000		None
November 8	3,800	0.4	0.000	0.70	
November 9	3,840	1.0	0.000		None
November 13	3,900	1.0	0.000		None
November 19	4,040	1.0	0.000		None
November 22	4,150	1.0	0.000		None
November 26	4,270	1.0	0.000		None
December 4	4,470	1.0	0.000		None
December 11	4,700	1.0	0.000		None
December 17	4,820	1.0	0.000		None
December 19	4,900	1.0	0.000	1.80	None
December 21	4,960	2.0	0.000		None
December 26	5,020	2.0	0.000	2.02	None
December 28	5,100	4.0	0.000		None
January 31	5,140	4.0	0.000	2.52	None
February 1	5,200	10.0	0.000 Tr.	3.12	Very slight on standing 2 hours
February 4	5,242	100.0	0.000 Tr.	7.32	Very slight on standing 2 hours

in the same manner as the Darco filter. Making allowance for the phenol adsorbed by the bone char that was mixed with the Darco,

TABLE 2

Phenol adsorbed by Minchar

The bed contained about 700 grams of Minchar

DATE (1928–1929)	LITERS FILTERED	PHENOL ADDED	PHENOL IN EFFLUENT	TOTAL PHENOL ADSORBED	TASTE OF EFFLUENT AFTER ADDING 0.25 P.P.M. CHLORINE
		p.p.m.	*p.p.m.*	*grams*	
October 23	0				
October 23	20	0.4	0.000		None
October 24	60	0.4	0.000		None
October 25	110	0.4	0.000		None
October 26	150	0.4	0.000		None
October 30	210	0.4	0.000		None
October 31	250	0.4	0.000		None
November 1	300	0.4	0.000		None
November 2	340	0.4	0.000		None
November 7	410	0.4	0.000		None
November 8	460	0.4	0.000	0.18	None
November 9	500	1.0	0.000		None
November 13	550	1.0	0.000		None
November 15	620	1.0	0.000		None
November 19	720	1.0	0.000		None
November 22	840	1.0	0.000		None
November 23	880	1.0	0.000		None
November 26	950	1.0	0.000		None
December 4	1,150	1.0	0.000		None
December 11	1,360	1.0	0.000		None
December 17	1,500	1.0	0.000		None
December 19	1,590	1.0	0.000	1.31	None
December 21	1,640	2.0	0.000		None
December 26	1,680	2.0	0.000 Tr.	1.49	Very slight iodoform
December 28	1,760	4.0	0.011	1.81	Slight iodoform
January 31	1,810	4.0	0.012	2.01	Slight iodoform
February 1	1,860	10.0	0.108	2.50	Strong iodoform

the results indicate that equal weights of Darco will remove about 25 times as much phenol as Minchar. It is admitted that this comparison is not very accurate.

The adsorptive capacity of several of the activated carbons was tested in another way. Samples of the materials were pulverized to pass a 200 mesh sieve and 1-gram samples were added to 1-liter

TABLE 3

Phenol adsorbed by 1 gram of activated carbon

Pulverized to pass 200 mesh sieve. Solution stirred four hours.

DARCO			NUCHAR		
Phenol added to 1 liter of water	Phenol remaining in solution	Adsorbed	Phenol added to 1 liter of water	Phenol remaining in solution	Adsorbed
mgm.	*p.p.m.*	*per cent*	*mgm.*	*p.p.m.*	*per cent*
2.5	0.0000	100.0			
3.0	0.0000	100.0			
4.0	0.0000	100.0			
4.5	0.0000	100.0			
5.0	0.0007	99.9	5.0	Trace	99.9
7.5	0.012	99.8	7.5	0.011	99.8
10.0	0.040	99.6	10.0	0.032	99.7
12.5	0.108	99.1	12.5	0.081	99.3
15.0	0.223	98.5	15.0	0.151	99.0
20.0	0.542	97.3	20.0	0.335	98.3

TABLE 4

Phenol adsorbed by 1 gram of material

Pulverized to pass 200 mesh sieve. Solution stirred one hour, except in the case of Minchar, which was stirred four hours.

PHENOL ADDED TO 1 LITER OF WATER	MINCHAR		BONE BLACK		WOOD CHAR	
	Phenol remaining in solution	Adsorbed	Phenol remaining in solution	Adsorbed	Phenol remaining in solution	Adsorbed
mgm.	*p.p.m.*	*per cent*	*p.p.m.*	*per cent*	*p.p.m.*	*per cent*
0.05	Trace	100.0–			0.0045 0.0045	91.0
0.10	0.032	68.0	0.032	68.0	0.036	64.0
0.15	0.060	60.0				
0.20			0.092	54.0	0.092	54.0

portions of water containing various quantities of phenol. The results are summarized in tables 3 and 4. The results for Darco are plotted in figure 1. It will be noted that the curve follows the Freundlich adsorption equation $a = \alpha c^{\frac{1}{n}}$ very closely when "α" is 4.08 and "n" is 4.0.

If the theory of adsorption is correct, complete removal of phenol is not accomplished, but the curve rises quite rapidly at first and there is considerable adsorption before enough phenol will remain in solution to cause a chlorophenol taste. It is not believed that 0.001 p.p.m. of phenol can, under any condition, be made to produce a taste, and so long as this amount is not exceeded there should never be a taste produced by the phenol alone. Our own experiments have shown the taste-producing concentration of phenol to be near 0.005

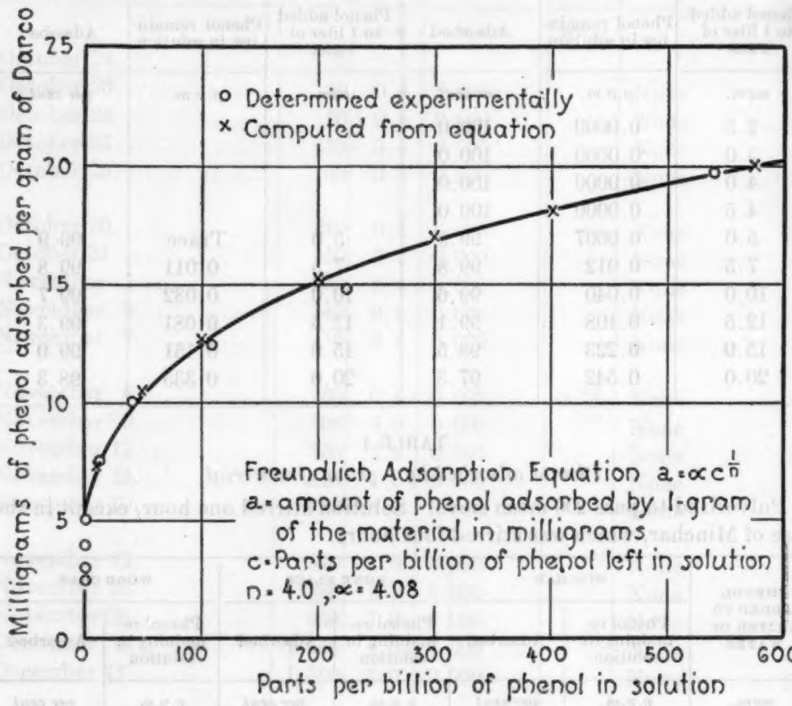

FIG. 1

p.p.m., but others have found the point to be lower. There is no reliable information indicating that the taste-producing point is less than 0.002 p.p.m., consequently when 0.001 p.p.m. phenol remaining in solution is set as the maximum adsorptive capacity of carbon, there should be no danger of the phenol alone producing taste after chlorination of the water.

It will be noted from table 3 that Darco and Nuchar will adsorb approximately 5 mgm. of phenol per gram of material before 0.001

p.p.m. of phenol remains in solution. This is an adsorptive capacity of approximately 0.5 per cent of the weight of the material. Tables 1, 2, and 5 show that considerably more phenol is actually adsorbed in a filter bed when high concentrations of phenol are used. This probably is due to the carbon in the upper part of the bed adsorbing considerably more phenol than that in the lower part; that is, the the phenol concentration diminishes as the water passes through the bed and the equilibrium where the water contains considerable phenol is very much higher. This makes such materials particularly

TABLE 5

Removal of phenol from a solution containing 200 p.p.m. of phenol

The solution was filtered through a bed of granular (4 to 12 mesh) Darco approximately 2 feet deep. The material was not weighed, but approximately 300 grams of Darco were used. The solution was filtered at the rate of about 2 gallons per square foot per minute. This is customary filtration rate for rapid sand filters. This is not a continuous run, but the filter was run several hours on the dates given.

DATE (1929)	LITERS FILTERED	PHENOL IN APPLIED WATER	PHENOL IN FILTERED WATER	TOTAL PHENOL REMOVED	TASTE OF THE FILTERED WATER AFTER ADDING CHLORINE
		p.p.m.	*p.p.m.*	*grams*	
February 6	18	200	0.000	3.6	No taste
February 8	40	200	0.000	8.0	No taste
February 11	54	200	0.000	10.8	No taste
February 14	78	200	0.000	15.6	No taste
February 15	106	200	Trace	21.2	Slight taste
February 18	130	200	Over 0.500	26.0	Strong iodoform

If 300 grams of Darco was used, about 7 per cent of its weight was adsorbed before phenol began to pass the bed in quantities that would give a taste after the addition of chlorine.

adapted for handling occasional high phenol occurrences, which is the way phenol pollution usually occurs.

Darco weighs about 18 pounds per cubic foot, consequently a bed 2 feet deep will remove about 0.18 pound of phenol per square foot to the point where there will be no taste, taking the results for maximum adsorptive capacity as given in table 3. If beds actually behave like the results shown in tables 1 and 5, then the amount removed will be very much more. Filtering water at the rate of 2 gallons per square foot per minute that contains an average of 0.005

p.p.m. of phenol, it would take over four years for the Darco to become saturated with phenol to the extent that an amount sufficient to produce a taste will pass the bed. The phenol concentration in many instances goes higher than 0.005 p.p.m. for short periods, but there probably is not a water supply in the country having an average higher than this figure.

Howard (see Enslow, "Progress in Chlorination of Water") gives the added cost incurred by super-chlorination at Toronto to be approximately 78 cents per imperial million gallons (about 65 cents per U. S. million gallons). The average amount of water treated was 74.78 million imperial gallons daily. This would be a total of approximately 32,800 million U. S. gallons annually. Should the water have averaged 0.005 p.p.m. of phenol, an amount very likely considerably in excess of what it did contain, there would have been a total of 1370 pounds of phenol in the water for the year. If it requires 200 pounds of Darco to remove 1 pound of phenol, it would require 274,000 pounds of the material to have removed the 1370 pounds of phenol. At a price of 10 cents per pound for the active carbon, the cost per million gallons would be about 84 cents for the material alone. Full value probably could not be derived from the material, and considering the cost of handling together with interest and depreciation on the plant, the total cost may be about $1.50 per million gallons. This is providing the carbon could not be revivified. At the present time we are not sure but what the carbon will become poisoned by other compounds removed from the water and the total adsorptive capacity may be cut down somewhat. On the other hand, phenol usually occurs intermittently and there may be a tendency for the carbon to dephenolate itself during times when there is no phenol in the water. This is what should be expected if the adsorption theory is correct, although it is known that the retentive capacity of carbon is high for some compounds.

The writer is of the opinion that a bed of one of the more active carbons such as Darco, when filtering perfectly clear water all the time, would never become saturated with phenol to the extent that phenol will pass the bed in objectionable quantities if the carbon did not become poisoned by some other compound or compounds. This is based on the amount of phenol that will likely occur in any water supply at the present time. It is safe to assume at the present time that the carbon will not remain active for phenols more than two or three years without revivification.

To illustrate the reliability of activated carbon in removing phenol from water, the drinking water that was given away at the Chicago experimental plant during the past winter was passed through a bed of Darco. On several occasions phenol was present in the city water to the extent that there was a distinct chlorophenol taste. Without giving the occurrence any attention, or changing the treatment in any respect, the water was made perfectly palatable by passing it through the bed of Darco. No chemist had to be on duty to tell when the occurrence started or to determine the treatment. The filter is there ready to take out any amount of phenol that is likely to occur in the water, or even a hundred times as much as has ever occurred in any water supply.

TABLE 6

Loss of ignition of various carbons

The materials were dried several hours at 110°C., and then ignited in a muffle furnace for two hours at a bright-red heat. The loss on ignition gives some indication of the carbon present.

MATERIAL	LOSS OF WEIGHT AFTER IGNITION
Wood char (not activated)	96.5
Minchar	7.6
Nuchar	92.7
Bone char	16.4
Darco	71.0
Morrell char No. 2	96.0

DE-CHLORINATION

Many waters are polluted with such a variety of compounds that it may be more advantageous to super-chlorinate to break down such compounds as may be attacked by the chlorine, and then use the activated carbon for de-chlorination and the removal of certain compounds not attacked by the chlorine. It may be that this procedure would result in the removal of practically all taste-producing compounds. It is the opinion that it will come nearer removing them all than the use of either super-chlorination or the active carbon alone.

Watzl (13) states that certain charcoals are suitable for de-chlorination and that the reaction is an oxidation of the carbon. Our work tends to confirm the claim of Watzl. One pound of carbon

will convert approximately 12 pounds of chlorine to hydrochloric acid. No commercial activated carbon which may be used in the granular form for filtering contains 100 per cent carbon. Table 6 shows quite a wide variation in the loss on ignition of a few of the active carbons. It is likely that practically all carbon in these materials was burned at the high temperature used, but the total loss on ignition may be slightly in excess of the carbon present. It should be evident that all the carbon in any material would not be available for de-chlorination, for much of it would break up and go off with the water as very fine particles. If only one-fifth of the carbon in such materials as Darco and Nuchar were available for de-chlorination, it would still be cheaper than sulfur dioxide, providing it did not involve handling costs greatly in excess of the sulfur dioxide.

It was the work being done at Cleveland that first called the writer's attention to the possibility of using certain forms of carbon for de-chlorinating water. The process, however, is not new, for the Candy Filter Company in England has used carbon for dechlorination for nearly 19 years (14). Our first de-chlorinating experiment was an attempt to dephenolate a bed of Darco that had been in contact with a 2.5 per cent solution of phenol. One of the laboratory filters was filled with about 300 grams of 4 to 12 mesh granular Darco, and was allowed to stand in contact with the strong phenol solution for about eighteen hours. The filter was then washed every few days for about two and one-half months. At the end of this time the solution standing in contact with the Darco over night showed 0.082 p.p.m. of phenol. This was prior to starting the de-chlorinating experiment. The fact that after a number of washings within a period of two and one-half months the carbon still gave up phenol to the water indicated there was no conversion, or at least no rapid conversion of the adsorbed phenol to some other compound by the carbon. The writer at first thought there was the possibility of the carbon acting as a catalyst.

The de-chlorinating experiment shown in table 7 was then started and was run continuously for a period of thirty-one days, using the same material that had been in contact with the phenol solution. Chlorinated Chicago water was used. The temperature of the water was not measured, but it did not vary greatly from 5°C. It will be noted that the water was passed through the filter quite rapidly. The flow was upward so that there would not be much loss of head.

It is evident at this high rate that the material was partially suspended, but the rate was not great enough to wash much of it away. The fact that the material was in state of constant motion somewhat as the sand in a filter bed during the washing period, it gives indication that the Darco will stand considerable handling without much

TABLE 7
De-chlorination with Darco

DATE (1920)	RATE OF FLOW	RESIDUAL CHLORINE IN APPLIED WATER	RESIDUAL CHLORINE AFTER PASSING THE BED OF DARCO
	gallons per square foot per minute	*p.p.m.*	*p.p.m.*
February 1	13.7	0.29	0.03
February 2	13.0	0.38	Tr.
February 4	13.0	0.29	Tr.
February 5	13.0	0.33	0.04
February 6	13.4	0.32	0.03
February 7	13.4	0.32	0.03
February 8	13.4	0.29	0.04
February 9	13.7	0.25	0.03
February 11	13.7	0.21	0.03
February 13	13.7	0.25	0.05
February 14	13.7	0.22	0.03
February 15	13.7	0.17	0.03
February 18	13.7	0.20	0.04
February 19	13.7	0.17	0.03
February 20	13.7	0.17	0.04
February 21	13.7	0.21	0.05
February 22	13.7	0.18	0.04
February 25	13.7	0.21	0.03
March 4	13.7	0.21	0.05

loss. The experiment shows that most of the residual chlorine was removed even at this high rate. Reducing the rate to 4 gallons per square foot per minute, all the residual chlorine was removed.

At the end of the experiment shown in table 7, water containing 1 p.p.m. of phenol was run through the bed at the rate of about 2 gallons per square foot per minute. All of the phenol was removed,

showing that the Darco was at least partially revivified. Thirty-seven liters of water containing 1 p.p.m. of phenol were run through at customary filtration rate, then the concentration of the phenol in solution was changed to 100 p.p.m. At first, all of the phenol was taken out of this solution, but after 24 liters had been run through considerable phenol was passing the filter. Fully 0.2 gram of phenol was adsorbed by the 250 grams of Darco before phenol in quantities that would cause a taste passes the filter. There is some doubt as to whether the chlorine dephenolated the carbon or the phenol was merely washed away. The residual chlorine was not high and it may not have been sufficient to break down the phenol. The significant fact is that the phenol was removed to the extent that it would again adsorb all the phenol from water highly polluted with phenol.

Without changing the Darco in the filter, the residual chlorine was increased in the water to see if there was any point where the active carbon would not remove all the free chlorine. The concentration was increased higher and higher until finally it was run up to more than 3000 p.p.m. of residual chlorine. In this case the chlorine water solution was made as strong as it was possible to make with a Wallace and Tiernan chlorine machine. Since there was some loss of Darco from previous use and the material had been used for several experiments, a fresh lot of the material was used for the next experiment.

Three hundred grams of the 4 to 12 mesh granular Darco was added to the laboratory filter, and this filled it to approximately 24 inches in depth. The filter was operated at a rate that would give not more than a trace of residual chlorine in the effluent. The results are shown in table 8. For the particular filter used, 146 cc. per minute is equivalent to 2 gallons per square foot per minute. It will be noted that the filter could be operated at about 1.4 gallons per square foot per minute at first, but at the end of the experiment the rate had to be reduced to 0.7 gallon. After about 130 liters of the solution had been filtered through, representing the conversion of about 445 grams of chlorine to hydrochloric acid, the filtrate began to show a brown color. The color increased as the experiment continued until the solution was so dark when 190 liters has been filtered that the experiment had to be abandoned. The dark brown color was due to a disintegration of the Darco. Examination under the microscope indicated a colloidal suspension. The particles are so fine that the solution probably would never settle clear.

TABLE 8

De-chlorination with Darco

Strong chlorine solution used. Three hundred grams of Darco added to glass tube. Tube filled to about 24 inches.

LITERS FILTERED	RESIDUAL CHLORINE IN APPLIED WATER	RESIDUAL CHLORINE IN FILTERED WATER	N/10 SODIUM HYDROXIDE TO NEUTRALIZE 10 CC. OF SOLUTION	RATE OF FLOW	CO_2 IN SOLUTION
	p.p.m.	*p.p.m.*	*cc.*	*cc. per minute*	*p.p.m.*
2	3,278	0.00	5.5	100	
4	3,278	0.00	7.4	106	
6	3,278	0.10	8.0	144	145
8	3,278	Trace	8.1	100	174
10	3,278	0.00 Trace	8.5	100	229
12	3,278	0.00 Trace	8.4	100	233
14	3,278	0.00 Trace	8.6	100	236
16	3,278	0.00 Trace	8.6	100	266
18	3,278	0.00 Trace	8.6	100	270
20	3,101	0.00 Trace	8.3	100	270
22	3,101	0.00 Trace	7.8	110	270
24	3,101	0.00 Trace	7.9	100	266
26	3,101	0.00 Trace	8.3	100	270
28	3,101	0.00 Trace	8.4	100	266
30	3,101	0.00 Trace	8.4	100	266
32	3,101	0.00 Trace	8.5	100	268
34	3,101	0.00 Trace	8.5	100	268
36	3,101	0.00 Trace	8.5	100	260
38	3,542	0.10	8.4	100	238
40	3,542	0.30	8.3	100	255
50	3,542	0.00 Trace	9.6	80	326
60	3,567	0.20	9.3	96	268
70	3,567	0.00 Trace	9.5	50	304
80	3,989	0.00 Trace	10.1	50	362
90	3,987	.10	10.8	60	403
100	3,455	0.00 Trace	9.3	52	305
110	3,455	0.00 Trace	9.4	56	356
120	3,384	0.00 Trace	9.6	56	266
130	3,384	0.00 Trace	9.6	54	306
140	3,532	0.00 Trace	9.6	60	374
150	3,632	0.00 Trace	10.1	40	396
160	4,004	0.00 Trace	10.6	54	517
170	4,004	0.00 Trace	10.7	56	636
180	3,278	0.00 Trace	10.0	54	970
190	3,278	1.00	8.9	50	260

Note: 146 cc. per minute equals 2 gallons per square foot per minute.

In addition to the CO_2 remaining in solution as shown by the figures in table 8, there was almost a continuous stream of gas bubbles passing off and escaping to the air. This is why the CO_2 test did not show as much CO_2 as there should be to account for the carbon that was oxidized. Tests for dissolved oxygen in the filtrate showed none, or only a trace present, indicating that the reaction is not a conversion of the nascent oxygen to O_2 as the writer at first thought was the case. The experiment given in table 8 is of no significance except to show that active carbon will de-chlorinate any amount of residual chlorine that may be added to water. It is merely a question of giving sufficient contact time. In this experiment Darco converted approximately 1½ times its weight of chlorine into hydrochloric acid before disintegration of the material caused a discoloration of the water. With a residual somewhere near what would be used in practice we have no information as to what will happen after prolonged use. To see if the material was spoiled for future use after being in contact with such a strong solution of chlorine, it was washed to remove all the fine disintegrated material and water having a residual chlorine content of about 1 p.p.m. was passed through it. At first the solution came out discolored, but after a few days it cleared up and at this writing is giving satisfactory de-chlorination of the water.

REDUCTION OF OXIDIZABLE ORGANIC MATTER

The edition of an excess of chlorine to water results in the conversion of some of the taste-producing compounds to compounds that give little or no taste. The addition of sulfur dioxide probably does nothing more than remove the excess of chlorine, that is, converts it to hydrochloric acid. The addition of potassium permanganate probably results in the oxidation of some of the organic compounds. All such treatments remove little or nothing from the water, but convert part of the offensive compounds to inoffensive compounds. The active carbons actually remove certain constituents of the water. In this respect they should give results more satisfactory than other treatments. It is evident of course, that, if the cost is excessive, such materials could be used only to a limited extent.

The experiment given in table 9 shows that there is both a reduction in the oxygen consumed and the amount of chlorine that the water will take up after passing the water through the carbon filter. This indicates a reduction in the oxidizable matter in the water. The

TABLE 9

Reduction in oxygen consumed and chlorine absorption by passing water through a bed of activated carbon

Filter 8, which has an area of 10 square feet, was filled 2 feet in depth with 4 to 12 mesh granular "Darco." With the exception of Sundays, it has been in continuous operation since December 28, 1928. Filtered water from Filter 9 is passed upward through the bed of carbon. In the chlorine adsorption test, known amounts of chlorine were added to samples of water from Filters 9 and 8. No chlorine was added prior to filtration through either filter.

DATE (1928-1929)	OXYGEN CONSUMED		CHLORINE					
			Filter 9			Carbon Filter		
	Filter 9	Filter 8 (carbon)	Added	Residual	Absorbed	Added	Residual	Absorbed
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
December 28	1.9	1.0	0.24	0.14	0.10	0.24	0.18	0.06
December 28	1.8	0.8	0.24	0.12	0.12	0.24	0.18	0.06
December 28	1.9	0.8	0.24	0.14	0.10	0.24	0.18	0.06
December 29	2.0	0.8	0.24	0.12	0.12	0.24	0.19	0.05
December 29	1.8	0.9	0.28	0.16	0.12	0.28	0.23	0.05
January 2			0.24	0.13	0.11	0.24	0.18	0.06
January 3			0.22	0.11	0.11	0.22	0.18	0.04
January 3	1.6	1.0	0.22	0.12	0.10	0.22	0.18	0.04
January 7			0.24	0.20	0.04	0.24	0.18	0.06
January 8	1.9	1.2	0.26	0.14	0.12	0.26	0.20	0.06
January 11	1.9	1.1	0.24	0.17	0.07	0.24	0.19	0.05
January 15	1.9	1.3	0.18	0.10	0.08	0.18	0.14	0.04
January 17	1.6	1.2	0.18	0.12	0.06	0.18	0.14	0.04
January 19	1.8	1.4	0.24	0.17	0.07	0.24	0.19	0.05
January 21	1.7	1.3	0.24	0.16	0.08	0.24	0.20	0.04
January 24	1.7	1.1	0.22	0.12	0.10	0.22	0.16	0.06
January 29	1.5	1.1	0.30	0.19	0.11	0.30	0.24	0.06
February 1	1.3	0.9	0.30	0.18	0.12	0.30	0.25	0.05
February 5	1.4	0.9	0.24	0.14	0.10	0.24	0.19	0.05
February 7	1.3	1.0	0.24	0.14	0.10	0.24	0.18	0.06
February 9	1.6	1.2	0.30	0.19	0.11	0.30	0.24	0.06
February 13	1.4	1.0	0.24	0.13	0.11	0.24	0.18	0.06
February 15	1.4	0.9	0.24	0.12	0.12	0.24	0.18	0.06
February 18	1.4	1.0	0.30	0.20	0.10	0.30	0.24	0.06
February 21	1.5	1.3	0.34	0.22	0.12	0.34	0.26	0.08
February 25	1.5	1.2	0.24	0.14	0.08	0.24	0.19	0.05

experiment given in table 10 shows that Darco has the power of removing, at least for short periods, considerable increase in the oxidizable matter. The increase of oxygen consumed over the normal

on three occasions represents pollution from a by-product coke-oven plant being added to the water. The results show that the carbon is very effective in removing the added compounds whereas ordinary wood charcoal not activated reduces the oxygen consumed very little.

By super-chlorinating highly polluted water and then de-chlorinating with an active carbon the oxygen consumed figure could be reduced quite low for almost any reasonable amount of pollution. In fact, it is believed that the effluent from a well operated sewage disposal plant, by using both sedimentation and filtration, can be made into pure and palatable water. It probably would have to be aerated, treated with a coagulant such as aluminum sulfate, filtered through an ordinary rapid sand filter, chlorinated to excess, and then filtered through a bed of active carbon. It is evident that such a treatment would not be economical where a less polluted supply is available, but there are places in the arid regions where water is very scarce and it may be more economical to purify a highly polluted water than to bring a less polluted supply from a great distance.

TABLE 10

Reduction in oxygen consumed by passing the water through a bed of Darco and a bed of wood charcoal not activated

TIME IN SERVICE	OXYGEN CONSUMED		
	Influent water	Effluent Darco filter	Effluent wood charcoal filter
days	*p.p.m.*	*p.p.m.*	*p.p.m.*
4	2.0	0.8	2.0
6	2.0	0.8	2.0
11	1.5	0.8	1.4
13	3.0*	0.6	2.8
17	1.7	0.7	1.6
20	4.2*	0.5	3.6
39	1.8	1.1	1.8
46	3.5*	0.4	3.3
63	1.4	1.0	1.4
88	1.8	1.3	1.7
100	1.1	0.9	1.0

* Pollution added.

PRACTICAL APPLICATION OF ACTIVE CARBON TO WATER TREATMENT

Any material which has to be used so sparingly cannot be economical in the pulverized form where it has to be mixed with the water, although no experiments so far have been run along this line. It would be much more economical to pass the water through a bed of the granular material. Probably the most satisfactory means of doing this is to have the beds constructed like the ordinary rapid sand filters, except that activated carbon will be used instead of sand. The water should be filtered clear before it reaches the carbon filters, otherwise the suspended matter may stop up the pores in the carbon granules. Figure 2 shows the arrangement of the filter at the

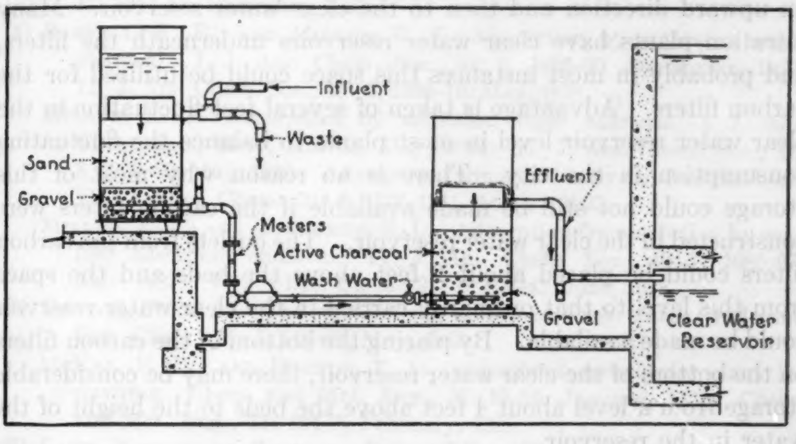

FIG. 2. ACTIVATED CHARCOAL FILTER

Chicago experimental filtration plant. It will be noted that the water flows upward through the carbon filter. By doing this only one rate controller need be used, for the flow through the carbon filter is dependent entirely upon the flow through the sand filter.

Regardless of how clear water may be filtered there is always enough sediment passing the filters eventually to clog a second filter if the flow is downward. With an upward flow there should be no material clogging, that is, to the extent of causing considerable loss of head. At this writing the bed of 4 to 12 mesh granular Darco in the experimental plant has been in continuous service, except Sundays, for nearly four months without being washed or disturbed in any manner whatever. The rate of filtration has been 2 gallons

per square foot per minute. The loss of head through the gravel bed and the Darco bed was 3 inches when the experiment started and it was still 3 inches nearly four months afterwards. A carbon bed should be constructed, however, so that it may be washed occasionally, but the less it is washed the less will be the loss of carbon.

Where filtration plants have not been constructed already a two-story filter probably will be the cheapest construction. Accurate estimates have not been made, but it is believed that in most instances the added cost to the entire plant will be less than 5 per cent. With this arrangement water will pass through the sand bed as usual, through the rate controller, and then into a system of laterals at the bottom of the carbon filter. It will pass through the carbon bed in an upward direction and then to the clear water reservoir. Many filtration plants have clear water reservoirs underneath the filters, and probably in most instances this space could be utilized for the carbon filters. Advantage is taken of several feet fluctuation in the clear water reservoir level in most plants to balance the fluctuating consumption in the city. There is no reason why most of this storage could not still be made available if the carbon filters were constructed in the clear water reservoir. The outlets from the carbon filters could be placed about 2 feet above the beds and the space from this level to that ordinarily carried in the clear water reservoir could be made available. By placing the bottom of the carbon filters on the bottom of the clear water reservoir, there may be considerable storage from a level about 4 feet above the beds to the height of the water in the reservoir.

One hundred and fifty gallons per capita per day is a fair average of the water consumption over the country. This is approximately 55,000 gallons a year. The average cost of filtering water throughout the country where there are no unusual conditions is about $10.00 per million gallons. This means that it is costing the consumers about 56 cents each year for the privilege of having filtered water. This is in addition to the interest and depreciation on the plant, which may amount to one-half the operating cost. All costs average perhaps less than $1.00 per capita per year for the average city. If the expense of making the water perfectly palatable all the time were $1.50 per million gallons for all costs, this would add about 9 cents per year to the cost of our water where 150 gallons per capita per day is used. Certainly this would not produce a burden on any

one, even if the cost were two or three times this amount. We frequently spend that much extra on a single meal just to get something more appetizing. There is nothing that will produce a larger return in satisfaction on the investment than elimination of taste where water frequently or only occasionally has a bad taste.

The laboratory tests in connection with this work were made by Oscar Gullans.

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CHLORINE INSTITUTE STANDARD VALVES FOR CHLORINE CONTAINERS UNDER FIFTEEN TONS CAPACITY[1]

By Robert T. Baldwin[2]

On October 13, 1926, the Fifth Session of the Public Health Engineering Section, American Public Health Association, at Buffalo, New York, by appropriate motion authorized the Secretary of the Section to communicate with The Chlorine Institute, Inc., and the American Water Works Association with reference to the standardization of valves for chlorine containers. The Chlorine Institute, Inc., received the resolution and through the work of its Committee on Container Specifications and Safety has approved and adopted standard valves for chlorine containers under 15 tons capacity. These valves are rapidly going into circulation and we shall presently have but one kind of chlorine valve in the sanitary field throughout Canada and the United States of America. They have passed very exacting criticism and tests and their use is not confined to Institute members. Recently these valves have been well tested in sulphur dioxide containers and appear to be suitable for that substance also.

We hear and read much about standardization, and find too great emphasis placed on the benefits to the consumer. The purveyor benefits also, but, best of all, both parties gain some measure of freedom that can be expended on more important things. In this case the user has but to learn the handling of one valve instead of several; his margin of safety is increased; he has one less worry. As for the chlorine maker, he does not have to maintain a tradition of his own or other's making that the particular valve or valves that he has used for years are distinctive and best. Such traditions or inattentions are often expensive if closely examined, but the general contrariness of human nature makes change difficult to accomplish.

The Committee handling this valve matter met at intervals; composed honest differences of opinion; discarded some cylinder caps;

[1] To be presented before Toronto Convention, June 26, 1929.

[2] Secretary, The Chlorine Institute, Inc., New York, N. Y.

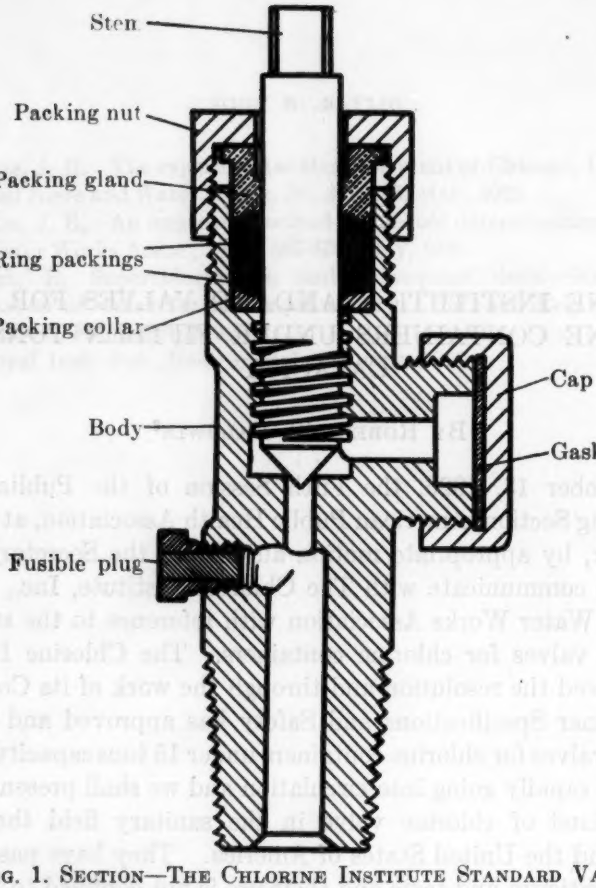

FIG. 1. SECTION—THE CHLORINE INSTITUTE STANDARD VALVE

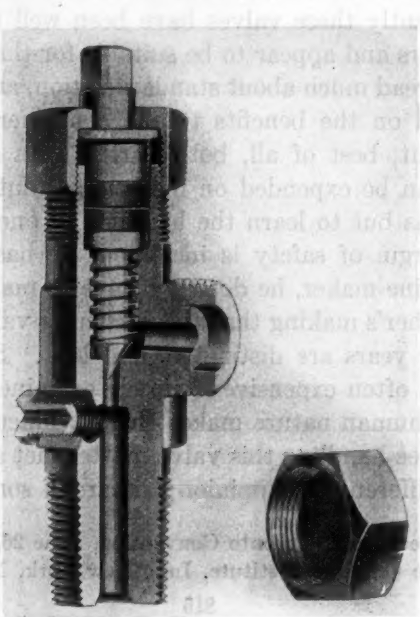

FIG. 2. THE STANDARD VALVE WITH ONE-QUARTER SECTION REMOVED

Fig. 3. The Standard Valve with Union Type Auxiliary Valve

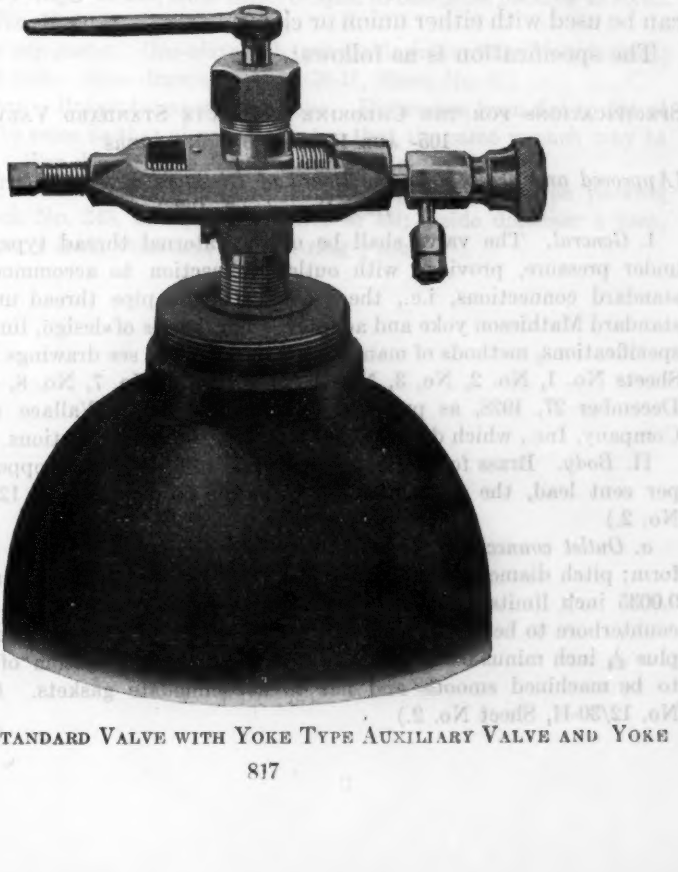

Fig. 4. The Standard Valve with Yoke Type Auxiliary Valve and Yoke

buried a few prejudices; had the very considerable services of one of its members, The Wallace and Tiernan Company, Inc., in furnishing drawings, expert advice and sample valves; and emerged from the proceedings and tests with a standard valve. The success of the Committee with this valve warrants the standardization of other chlorine container apparatus and the work goes on. There is, nothing extraordinary about it; a nice weighing of the factors and a will to have the thing done are the necessities. It is common sense, and after all, common sense is the essence of good engineering and safety.

Before quoting the specifications, it is to be noted that the valve with safety plug for the containers holding 100, 105 and 150 pounds of chlorine is adapted to both union and clamp fittings, and is suited to the thousands of connections now employed in the sanitary field. Exactly the same valve, except that it has a $\frac{1}{4}$ inch seat opening and no safety plug, is provided for the container holding 2000 pounds of chlorine. This ton container is equipped with safety plugs, three in each head, as described in "The One Ton Liquefied Chlorine Gas Container" (Jour. Amer. Water Works Assoc., October, 1927, pp. 417 et seq.). Like the other valve it fits all existing connections and can be used with either union or clamp.

The specification is as follows:

Specifications for the Chlorine Institute Standard Valve for 100-, 105- and 150-pound Containers

(Approved and accepted by the Board of Directors of The Chlorine Institute, Inc., December 7, 1928)

I. *General.* The valve shall be of the internal thread type, repackable under pressure, provided with outlet connection to accommodate present standard connections, i.e., the $\frac{3}{4}$ inch straight pipe thread union and the standard Mathieson yoke and adapter. For details of design, limits, material specifications, methods of manufacture and testing, see drawings No. 12/30-H, Sheets No. 1, No. 2, No. 3, No. 4, No. 5, No. 6, No. 7, No. 8, No. 9, dated December 27, 1928, as prepared by the courtesy of Wallace and Tiernan Company, Inc., which drawings are a part of these specifications.

II. *Body.* Brass forging consisting of 58 to 61 per cent copper, 1.5 to 2.5 per cent lead, the remainder zinc. (Shown on drawing No. 12/30-H, Sheet No. 2.)

a. Outlet connection. External $\frac{3}{4}$ inch straight pipe thread, 14 pitch, V form; pitch diameter 0.9830 inch plus 0.000 inch, minus 0.0005 inch to minus 0.0035 inch limits. Inside of outlet boss to be counterbored; diameter of counterbore to be 0.5625 inch plus 0.003 inch minus 0.003 inch; depth $\frac{11}{64}$ inch plus $\frac{1}{64}$ inch minus 0.000 inch; outer end of boss and bottom of counterbore to be machined smooth and flat to accommodate gaskets. (See drawing No. 12/30-H, Sheet No. 2.)

b. Shank thread. Standard Briggs pipe taper of such size as to enter a ¾ inch Briggs Standard Pipe Gauge ½ to one turn. Threads to be 1⅛ inch long; increased diameter to be in accordance with Briggs standard taper for over-length threads. Standard oversize for oversize cylinder threads shall be same as above with exception that the thread shall be $\frac{1}{16}$ inch oversize in pitch diameter. In both cases the thread shall conform to the Briggs standard pipe thread without flats. (See drawing No. 12/30-H, Sheet No. 2.)

c. Seat. Integral with body, not renewable. Three-sixteenths inch opening for 100-, 105- and 150-pound containers. (See drawing No. 12/30-H, Sheet No. 2.)

III. *Fusible plug and fusible metal.* The fusible plug shall consist of a threaded bronze container to screw into the valve body. The fusible metal shall be Niagara Alkali Company, i.e., Jaeger Salts formula. (Details shown on drawing No. 12/30-H, Sheet No. 3.)

IV. *Stem.* Monel metal with ⅝ inch by 8 Acme right hand thread, rotating type. Top of stem to be ¾ inch square. No handle required. (See drawing No. 12/30-H, Sheet No. 4.)

V. *Packing nut.* Brass, external type; 1⅛ inch by 18 thread. (See drawing No. 12/30-H, Sheet No. 5.)

VI. *Packing gland.* Brass; shaped to compress packing to stem. Clearance between follower and stem to be increased a short distance from the lower end to avoid freezing. (See drawing No. 12/30-H, Sheet No. 6.)

VII. *Packing ring.* Brass; loose collar shaped to compress packing to stem. (See drawing No. 12/30-H, Sheet No. 7.)

VIII. *Outlet cap gasket.* One-sixteenth inch Garlock No. 902, or equivalent; diameter 0.960 inch. (See drawing No. 12/30-H, Sheet No. 8.)

IX. *Outlet cap.* Brass; hexagonal in shape. Dimension from flat to flat of hexagon shall be same as that of packing nut so that the same wrench may be used for both. (See drawing No. 12/30-H, Sheet No. 9.)

X. *Packing.* Shall consist of two self-lubricating split ring type packing such as Garlock No. 343, or equivalent, free of oil; inside diameter ½ inch, outside diameter ⅞ inch, thickness of each ring ¼ inch.

SOME NOTES ON PIPE PRACTICE IN EUROPE[1]

By R. H. Keays[2]

The writer, in connection with his engineering work on the new water supply of the city of Athens, Greece, has had occasion to review the pipe situation in Europe and has made some notes which may be of interest to the profession in America.

Such a great difference in price of pipe delivered in Athens exists between that coming from America and that from Europe, that there is no doubt as to which should be chosen, regardless of difference in quality.

Much of the difference in price is due to the difference in freight rates. All our shipments from the industrial parts of Europe come in by steamer. There is no through railway freight traffic to Greece and railway freight cars are not adapted to hauling heavy freight over long distances.

Steel pipe for water supply purposes, as compared with cast iron pipe, seems to be used much more in Europe than is the practice in America. This arises in large part from the lesser cost of handling the steel and the less liability to damage. Facilities for handling freight are not well developed. The freight cars are small, port facilities for transferring freight are inadequate and much of the transfer from steamer to dock must be done by the use of lighters. Domestic transportation is mostly a matter of barges and canalized rivers.

The net result of these conditions is that steel pipe usually figures out as much cheaper than cast iron, whereas in the United States there is a real competition in the price of the two materials.

This argument applies with even greater force in the export business.

All of Europe is now organized on a strictly economic basis and purchasers are prone to accept the proposition that is cheaper in first cost regardless of quality.

[1] To be presented before the Toronto Convention, June 27, 1929.

[2] Ulen and Company, New York, N. Y.

This demand for cheapness is met by the manufacturers mainly by saving in the weight of metal furnished. Most of the cast iron water pipe of Continental Europe of French and German standards is lighter in weight than class "A" American pipe. Heavier pipe is not standard and must be manufactured special. In France for higher pressures some use is made of cast iron pipe reinforced by steel bands shrunk on. In England cast iron pipe is made in four different weights as in the United States.

It is claimed also in America that the quality of the cast iron in European pipe is not so good as it should be on account of the ore containing too much sulphur.

On the other hand, the street mains in Europe on account of the less use of water than in America average smaller in size, and the pressures carried are also less.

Small pipe is given a hydrostatic test of 25 atmospheres, and large pipe 15 atmospheres.

Steel pipe is usually of the Mannesmann or hub and spigot lap welded type. Riveted pipe is used very little. Most of this pipe is manufactured in Germany and Great Britain with some efforts in that line by Czecho-Slovakia. Mannesmann pipe is made in the smaller sizes up to 16 inches or more and lap welded steel in the larger sizes.

Mannesmann pipes due to the process of manufacture must have a relatively large wall thickness and so are unnecessarily strong and the expensive for ordinary purposes.

MANUFACTURE OF STEEL PIPE IN GERMANY

I was shown the whole process of making Mannesmann pipe at the Dusseldorf plant of the Vereinigte Stahlwerke. The whole process from the manufacture of the steel to the finished pipe is carried through in these works.

In the first process the ingot, say 4 feet long by 18 inches in diameter, is rolled and forged on the outside by four conical rolls, and is forced by hydraulic pressure against a short conical or rather bullet shaped mandrel. The mandrel is supported on a long stem which must be long enough to clear the full length of the pipe. This first process converts the ingot into a rough cylinder, the hole about the proper diameter, but the walls about 2 inches thick. The cylinder, of course, is much shorter than the finished pipe.

This cylinder is then placed without reheating in the second set of

rolls. In this case the mandrel is cylindrical and as long as the finished pipe, and it is attached directly to the ram. The rolls are peculiar in that for part of the circumference they are adapted to shape the outside of the pipe, while for the remainder of their circumference they clear the pipe.

The ram moves the pipe slowly through the rolls, but intervening between the ram and the end of the pipe are heavy springs. The result of this combination of the eccentric rolls working against the heavy springs is that a reciprocating movement is given to the pipe and the pipe is forged out to full length and is roughly finished.

The tubes are then reheated and passed through a set of rolls which fix the outside diameter of the pipe. There is no mandrel used and it is passed through four times, the pipe being rotated a little each time.

The last process is then to pass them without reheating through the finishing rolls. These are hour glass shape, the axis of the rolls being set at a flat angle with the pipe. This makes the pipe quite true to shape.

All the pipe I saw is threaded by hand on a lathe and comes in lengths of about 16 meters.

Much of this pipe is enlarged on one end for an inside thread and made smaller on the other end for an outside thread. One pipe is thus screwed into the other without the use of a coupling.

The principal order they had on hand at the time of my visit was for 850 kilometers of 16-inch Mannesmann pipe for an oil line from Baku to Batoum in the Caucasus.

At Bochum also in the Ruhr district is another large mill for the manufacture of Mannesmann pipe. The smaller sizes are made here and it is also one of the mills of the Vereinigte Stahlwerke.

This mill is quite modern and pipes of any length are made. I saw one on exhibition 35 meters long and 5 inches in diameter.

The gauge used for testing the thickness of the walls extends into the pipe four feet and if it tests all right all around the circumference, it is assumed that it is all right throughout.

Mannesmann tubes are tested as a matter of routine to 100 atmospheres and it takes 6 minutes to test each tube. The pipe is coated and wrapped only on the outside.

At Mulheim, also in the Ruhr, is the lap welded pipe plant of the Vereinigte Stahlwerke.

All steps from the ore to the completed product take place here.

The plant is new and they think nothing of putting up buildings 1800 feet by 1000 feet, all steel construction.

The manager says that American visitors assure him that it is the best steel plant anywhere. They claim the second widest sheet rolls in the world.

The sheets, as they come from the rolls, are sheared off to the right length and width for the pipes to be made. This means usually a sheet 8 meters long for the length of the pipe. The width is made such as to make up the full circumference of the pipe, with a proper lap, with only one sheet. The maximum circumference that can be covered with one sheet is about 12 feet.

The sheets are first sent to the bending mill. This consists of a set of three parallel rolls, the middle one of which is adjustable in a vertical direction and the outside ones in a horizontal direction. The plate is placed lengthwise in these rolls, passing over the two outside rolls and under the middle roll. The plate is then bent to the shape of the pipe by passing the plate back and forth in the rolls, depressing the middle roll and moving the outside rolls laterally to get the right curvature. When the right curvature and proper lap is obtained, the overlapping edges are clamped together and the embryo pipe is ready to go to the welding machine.

Welding process

The welding apparatus consists essentially of a carriage on which the pipe is placed, the carriage being movable longitudinal of the pipe. Projecting longitudinally into the pipe just under the joint, which is placed on top, is a long arm supported on a frame at the end. This arm is long enough to extend the full length of the pipe and carries near its end jets for burning water-gas, and a little closer in it is shaped to form an anvil.

Spanning the pipe on the outside is a yoked frame carrying the compressed air hammer, and also a water gas heating apparatus. The whole arrangement is such that the hammer can be placed opposite the anvil and the two gas heaters are also arranged opposite so the pipe can be heated inside and outside at the same time.

The actual welding is done by first heating the steel and then moving the pipe longitudinally until the heated place comes under the hammer, the welding in this case being by hammering rather than hydraulic pressure. The heating and hammering are done alternately. This process begins at the middle of the pipe and is carried alternately toward each end.

After the welding is done, the pipe is somewhat out of round and is rerolled to true it up.

It is claimed that this method of welding is better than electric welding as there is no overheating of the metal. The joint is specified as 90 per cent efficient. The weld is always thinner than the plate and they work to a tolerance of less than a millimeter.

On wide plates the plates are always thicker in the middle due to the spring of the rolls, and also in rolling the plates the plate can only be gauged once for each pass and that must be at one of the corners. This operation must be done quickly for the plate is rapidly cooling at this stage.

Forming bell and spigot

The next process is to square up the ends and at the same time form the bell and spigot.

The pipe is reheated on the ends and placed in a hydraulic press wherein the bell is formed by the hydraulic pressure and at the same time squared off to length and the proper diameter measured with a gauge. The bell is sometimes strengthened by folding over a short piece at end on the outside, and sometimes a reinforcing ring is put on. These are rolled and welded to the pipe in still another machine.

If the gauging shows that a bell or spigot is out of true or not exactly the right size, it is pressed into shape cold.

Defective bells and spigots are cut off and new ones formed.

The pipes are then ready for the hydrostatic test without passing first through an annealing furnace to relieve the internal strains in the weld.

The testing apparatus consists essentially of two circular plates faced with a gasket and properly mounted so that the ends of the pipe can be closed by these plates.

All these pipes are tested by the factory as a matter of routine and to pressures dependent on the thickness of steel, diameter of pipe and specifications of the customer. Very seldom do leaks develop on this test.

Pipes are gauged for thickness of sheet and weld by a gauge that extends into the pipe only four feet.

Coating of pipe

The pipes are then ready to be sent to the coating plant. This is a process that they do not consider so important in Europe as in America.

The pipe I saw being treated was not treated on the inside at all.

The pipe is first heated up a little on the inside by small gas flames distributed along its length and scraped to remove scale, after which a light coat of hot bitumen is applied to the outside.

Then the pipes are placed in a machine adapted to rotate the pipe and the wrapping is applied hot to the outside. The wrapping consists of strips of hessian or burlap soaked in hot bitumen and wound spirally on the outside.

The burlap is mounted on a spool and is led by a series of sheaves through the bath of hot bitumen. The rotation of the pipe furnishes the power necessary.

It is better to wind under rather than over as more of the bitumen gets between the pipe and the wrapping. As soon as the wrapping is completed there is some ground material sprinkled on the semi-fluid coating, while the pipe is still rotating. This material looks like marble dust. It dries up the bitumen and gives it a hard surface.

There seems to be a general impression among steel pipe manufacturers that it does no good to coat the inside of the pipe as it does not corrode.

Specials of all kinds are made to order, the welding being oxyacetylene. Testing and wrapping of these specials have to be done mostly by hand, and it is impractical to design machines for this purpose.

In shipping the pipe, the wrapping is more or less damaged and is scraped off in places, and the bells of course are not properly covered.

The manufacturers, therefore, ship along with the pipe a supply of bitumen and hessian for patching up the pipe just before placing the pipe in the ditch.

There is not much danger of the steel pipe itself being damaged in shipping. Part of the pipe we have received in Athens was loaded in steamers horizontally several tiers high. There were no protectors on the ends, but boards were placed between each tier so the bells could not bear on the pipes below. The rest of our pipe was supposed to be shipped vertically and two sizes nested, a wooden disk being bolted in each end as a protector and to hold them in position.

Practically none of any of this pipe was damaged, but there was considerable damage done to the coating.

During my short stay in Germany on this trip I did not find out anything about the cast iron pipe situation. The principal cast iron pipe manufacturers in Germany, I understand, are the Gel-

senkirchen Works, now claimed to be part of the Vereinigte Stahl Cartel. Officials of the Vereinigte Stahl seemed to be interested only in steel pipe and were discouraging the sale and use of cast iron pipe. This is a rather strange situation and perhaps I did not approach the subject along the right road. This Cartel method of organization in Germany is said to be quite complicated.

MANUFACTURE OF STEEL PIPE IN GREAT BRITAIN

In Great Britain also steel pipe is becoming a keen competitor of cast iron. This is largely due to the aggressive efforts of the steel companies to push their product. They recommend steel pipe in size down to the smallest laterals and have developed special methods of making house connections to steel pipe.

I had the pleasure of inspecting one of the large British works. It is not as complete or modern as those seen in Germany. The plates were not made in the same mill, but shipped in from outside.

The process here was in general the same as in Germany, differing however in two important particulars. The welds are not formed here by hammering as at Mulheim, but by hydraulic pressure on welding rolls, the welding apparatus otherwise being the same. The hubs and spigots are formed by rotating the pipe in properly formed rolls and not by hydraulic pressure as at Mulheim.

The pipe being manufactured here at the time was of 600 mm. and 750 mm. diameter and about 7.62 meters long.

The gauging apparatus only sticks into the pipe about a foot. When a weld is too thin, it is claimed that it is only thin in spots, due to variations in the pressure of the welding rolls and variations in the heating of the metal.

The pipe going through the mill at the time of my visit was being dipped and immediately afterward wrapped with hessian soaked in hot bitumen by a similar process to that used at the Mulheim works.

The inside of the pipe has a corrugated appearance due to the hot bitumen flowing in streams rather in a continuous sheet as the pipe rotates.

At this mill they also make bitumen lined pipe by the centrifugal process, similar to the Talbot process which is perhaps better known in America. This process gives a coating somewhat thicker than that obtained by dipping. The centrifugal machine turns at 500 revolutions per minute. The resulting coating is as smooth and shiny as glass.

The centrifugal process is supposed to throw the heavy filler out in contact with the steel leaving the bitumen on the inside. The inside surface, therefore, may be too soft.

In closing this paper the writer wishes to apologize for its sketchy nature, which is largely due to the haste with which the investigation was made and difficulty in getting the information.

Generally speaking such information is acquired rather slowly due to language troubles, lack of technical data in published form and trouble to find the man who has the exact information one wants. There is however no lack of courtesy or interest on the part of the manufacturers in giving any information in their power.

This paper may be of special interest at this time as having a bearing on the perennial dispute as to the relative merits of steel pipe versus cast iron pipe. It may serve to draw attention to the fact that this question is also being considered in countries outside of the United States. It may be worth while for American engineers to investigate thoroughly what is being done in Europe.

GROUNDING OF ELECTRICAL CIRCUITS ON WATER PIPES—THE WATER WORKS OPERATORS' ATTITUDE

On November 15 and 16, 1928, a general conference on Grounding was held in New York under the auspices of the National Fire Protection Association and representatives of the American Water Works Association attended and presented a brief statement of the water works operators' attitude on this subject. Mr. A. R. Small, Chairman of the Electrical Committee of the National Fire Protection Association, which committee prepares and issues the "National Electrical Code," presided at the conference. In addition to discussion of the subject Mr. Small requested all interested parties to submit to Mr. Blood, Chairman of the Committee responsible for Article 9 of the Code (covering Grounding), written statements of their comments, criticisms or suggestions on this article. In accordance with this request your representatives recently sent to Mr. Blood the following letter and received from Mr. Small the acknowledgment appended thereto.

March 16, 1929.

Mr. William H. Blood,
Chairman, Article 9 Committee,
National Fire Protection Association,
New York City.

Dear Sir:

Complying with the request of Mr. A. R. Small expressed at the conference on Grounding held November 15 and 16, 1928, at the Consolidated Gas Company Auditorium in New York City, that interested parties submit written statements of their criticisms, objections or proposed modifications of Article 9, we would submit the following:

MEMORANDUM FILED AT GROUNDING CONFERENCE

We take the liberty of bringing together in this one letter the statement of our attitude on Grounding as submitted at the above conference in order to bring together not only certain definite criticisms on the article itself, but the general background on which these criticisms are founded.

"In the first place, water works operators on perfectly reasonable grounds object to the use of their piping systems as conductors of electric current, and

to the transfer of any substantial part of the possible life or property hazard attaching to the operation of an electrical system from the system where it originates to a water piping system. For the present they do not object to *protective* grounding as such, provided the ground connections carry appreciable current only during the relatively short and infrequent periods when these connections are fulfilling their protective purposes.

"In the second place water works operators object to the interpretation of their sanction of the protective grounding of secondary electric distribution systems on water pipes as a license for the indiscriminate use of the piping system for electrical purposes, or as a current carrying part of the electric system. They most emphatically object to multiple water pipe grounds from primary distribution systems because of the increased hazard naturally attaching to the higher voltage circuits. With a higher voltage available for propagating current flow over the pipes, and with the general tendency to use individual primary phases to supply more or less isolated sections of a city or town, the tendency for substantial current interchange over the piping system is increased, and the hazard attached to such current interchange is augmented.

"In the third place, water works operators would point out that in spite of the 'continuous piping system' provision of the existing Electrical Code, no consideration is ordinarily given to the electrical continuity or discontinuity of the piping system either at the time when the ground connections are installed, or subsequently when pipe repairs or changes involving the use of non-metallic jointing material may have materially affected the electrical conductivity of the piping system.

"In the fourth place, water works operators would point out that although the Code refers to 'no appreciable potential difference' and 'no objectionable current flow' in connection with proposed ground connections, such connections are generally installed without test and without any regard to their possible effect on the piping system. Operators of electrical systems ordinarily do not appreciate the fact that ground connections which continuously transmit current to the pipes may be objectionable even though the current is alternating, and that in addition, ground connections from an alternating current system may carry substantial stray direct current, for example, from street railway systems. In either case, the ground connections may set up or aggravate electrolysis action on the pipes, or actually nullify the effectiveness of mitigative measures applied to protect the water pipes against electrolysis action. In special cases, even comparatively small currents may be objectionable from the water works' standpoint, and the practical interpretation of the grounding rules should take this into account.

"In the fifth place, and to more or less summarize the whole situation, the water works' attitude is that satisfactory grounding practices can only be established through a comprehensive coöperative study of all of the factors involved, and the adoption of a rigid supervisory policy regarding the installation and maintenance of ground connections. Provision should be made for testing the effect as well as the effectiveness of the ground connections, as they are installed and at periodic intervals thereafter, and all connections which are found to carry objectionable current either direct or alternating should be

omitted or eliminated. The present more or less haphazard method of installing and maintaining ground connections is unsatisfactory and at times hazardous from the standpoint of the water works operator, and it certainly cannot be considered an engineering solution of the safety problem.

"RESOLUTION MODIFYING STAND OF ASSOCIATION AS TO THE USE OF GROUNDING OF SECONDARIES OF LIGHTING TRANSFORMERS

"WHEREAS, this Association in 1920 endorsed the grounding of the secondaries of lighting transformers on water pipes as promoting the safeguarding of life and property without hazard to the pipe systems; and

"WHEREAS, experience with certain grounding practices, and certain trends in electrical distribution methods has shown that hazards to pipe structures and to water works employees have been and will be set up; and

"WHEREAS, certain trends in water works construction methods may seriously affect the conductivity of the water piping systems;

"*Be It Resolved*, that the American Water Works Association in convention assembled hereby modifies its 1920 endorsement of the grounding secondaries of lighting transformers as follows:

"(1) The American Water Works Association approves the practice of grounding the secondaries of lighting transformers on water pipes for the purpose of safeguarding life and property, provided that appreciable electric current flows over such ground connections only during comparatively short and infrequent intervals when the ground connections are fulfilling their specific protective purposes, and provided that such ground connections impose no responsibility upon the pipe owning company.

"(2) The American Water Works Association is opposed to the use of water pipes as electrical conductors, except as noted above, and since experience with certain power distribution practices which have come into use has shown that grounding may result, and in many cases has resulted in hazard to the pipe structures and water works employees, it hereby withdraws its former general endorsement of grounding on water pipes."

"OBJECTIONABLE GROUND CONNECTIONS

"1. Grounds which normally transmit appreciable alternating current to the water piping system.

"2. Grounds which transmit direct current to or from the water piping system.

"3. Grounds made to a metallically discontinuous piping system.

"4. Grounds which nullify existing electrolysis mitigative measures applied to the pipes.

"5. Grounds made at consumer's premises supplied from an underground cable system whose neutral conductor is connected to the sheath of the cables.

"6. All grounds from direct current systems.

"7. Power station and substation grounds which inter-connect pipe and cable systems otherwise electrically independent.

"8. Multiple grounds from primary electrical circuits.

"9. All ground connections made at inaccessible locations."

Referring directly to the Code, 1928 edition, we would make the following criticisms and suggestions:

Section 901 a. This statement is satisfactory to the water works interests, provided "no objectionable passage of current over the grounding conductors," means objectionable from the water works' point of view, and tests are made to determine first, if there is a current flow, and then the magnitude and character of this current. The water works interests are not satisfied with present practice which entirely ignores this fundamental restriction on ground connections. We believe provisions should be made to test all ground connections for current flow when they are installed and at intervals thereafter and that the results of these tests be supplied or at least made accessible to the operator of the water works system in question.

Section 901 b. This section refers to "a continuous-metallic underground water piping system," and we would point out that this cannot be taken for granted, but should be established by inquiry at the proper sources of information, or by test if necessary. We would also point out that with the extremely broad guarantee of safety to the water pipes which is contained in this paragraph, it is incumbent upon the "Code" enforcement agencies to see that the "no objectionable current" requirements are rigidly adhered to.

Section 901 c. No comment except to say that in a very large number of cases, metallic interconnections exist between piping systems in buildings, and a ground connection to a water pipe is in effect a ground connection to a gas pipe.

Section 901 d. No comment.

Section 901 e. This specifies limiting resistances for water pipe and other grounds. We believe the fine print note should stop after the word "resistance" because there is no more engineering logic in assuming that all water pipes will have a low resistance to ground than there is in assuming driven grounds will have a low resistance. Tests should be made in both cases.

901 f. No comment.

902 a, b. No ground connections from the positive side of a two-wire direct current system should be permitted, and all ground connections from direct current systems should contain suitable ammeters so that current flow on these ground connections can be more or less continuously observed. It is a well known fact that serious grounds often exist on the supposedly ungrounded conductors of direct-current distribution systems without detection until electrolysis failures of adjoining pipe or lead sheath cable systems lead to a detailed investigation.

902 c, d, e, f, g. No comment, if "no objectionable current," and "continuous metallic piping system" requirements are rigidly adhered to.

903 a. Putting in ground connections before interior wiring systems are connected to the distribution mains leads directly to violations of the "no objectionable current" and "shall not exceed 3 ohms" provisions of the Code unless the utility setting the meter is required to make adequate tests when the meter is set.

903 b. No comment.

904 a, b. No comment.

905 a, b, d. No comment.

905 c. No comment if "no objectionable current" requirement is rigidly adhered to.

906, complete. No comment except to say that ground connections should be installed so as to be accessible for test and for checking. At present this is not always the case.

907 a. No comment.

907 b. This refers to supply stations and puts in a restrictive clause "between which no appreciable difference of potential normally exists." This is good as far as it goes, but for the sake of uniformity at least, the "no objectionable current" restriction should also be added. At supply stations, all sorts of liberties are taken with piping systems in the way of connecting everything together electrically and letting currents flow where they will, with no regard for the hazard that may be set up on the pipes.

907 c. This paragraph should be more rigidly enforced than it is at present. Meter shunts are omitted oftener than they are installed.

907 d. Article 907 c reads in part: "The point of connection to the water piping system shall be located on the street side of the water meter. . . . ." Article 907 d reads in part: "The grounding conductor shall be attached to . . . . (2) by means of a brass plug screwed into the pipe and provided with a lug. . . . ." This second method of connecting should not be permitted because the water service pipe should not be disturbed by drilling and especially ahead of the meter.

907 e. Bonds between gas and water piping systems should also be subject to the "no objectionable current flow" restriction. They should be installed with considerable discretion, because in bad electrolysis areas one or both of the piping companies may be taking specific precautions to prevent metallic interconnections between the two systems, and the electric light installation should not nullify the electrolysis mitigative measures.

907 f. No comment.

908 complete. No comment.

We trust that the foregoing detailed comments together with our general statement submitted at the Grounding Conference will serve to acquaint you with the water works point of view on Grounding and on the 1928 grounding provisions of the "National Electrical Code." In conclusion, we would emphasize the fact that the water works interests, in submitting comments on the subject of ground connections, do not thereby accept any responsibility attaching to water pipe ground connections. We would also call your attention again to the present tendency in water works construction to use nonmetallic material for joints, which may materially affect the conductivity of the piping system in general.

Respectfully submitted,

NICHOLAS S. HILL,
EDWARD E. MINOR,
C. F. MEYERHERM,
Representing the American Water Works Association.

NATIONAL FIRE PROTECTION ASSOCIATION

Electrical Committee
A. R. Small, Chairman,
109 Leonard Street,
New York City.

April 3, 1929.

Mr. Chas. F. Meyerherm,
President and Engineer,
Albert F. Ganz, Inc.,
511 Fifth Avenue,
New York, N. Y.

Grounding (Article 9)

Dear Mr. Meyerherm:

Copies of enclosure with your valued favor of March 25th were distributed to the members present at the meeting of the Special Correlating Committee on Grounding of this Electrical Committee held on March 28th.

The action taken was to instruct the undersigned to acknowledge its receipt and to advise that its detailed consideration seemed outside of the authority of this special committee and that the communication would therefore be referred in due course to the incoming sub-committee on Article 9 for later detailed attention.

Respectfully,
(Signed) A. R. SMALL,
Chairman, Electrical Committee.

DISCUSSION

COMPOUND AND DETECTOR METERS

The writer has read with a great deal of interest, the discussion in The Journal on compound and detector meters.[1]

We have been through many of the experiences related and generally agree with the sentiment of the speakers against the use of compound meters and detector meters, except in very special cases. Several years ago we followed the suggestion of Mr. Beckwith and required a separation of fire and domestic or industrial services. In one instance, where we had been receiving a revenue of around $25 per quarter, the revenue jumped to about $300.

We passed an ordinance prohibiting the use of water for any purpose except for extinguishing fires, testing fire systems, etc., through a service equipped with a meter especially provided for this type of equipment. Still we had a lot of trouble with a few customers using water through these meters (all of our customers are metered, including fire lines). Mr. Beckwith mentions that about 30 per cent of the water going through a certain fire line was registered by the meter. This has also been, in general, our experience.

The purpose of this discussion, however, is not to relate any of the above, but we thought it would be interesting to know how we have met and, we believe, solved this problem. Based on the fact that the detector meters measure about one-third of the water passing through them, if they are used for ordinary domestic or industrial purposes, we succeeded in having the City Commission pass a rate schedule ordinance with an upward sliding scale instead of the conventional downward sliding scale. In other words, for the first 1000 cubic feet of water used over a sprinkler service we charge the same as we would on our regular rate schedule. Whereas, the second step of our regular rate schedule comes at the rate of 72 per cent of the charge for the first step, the second step of the fire sprinkler rate schedule is charged for at 322 per cent of the rate that we apply to the first step in the rate schedule.

[1] The Journal, February, 1929, page 229.

In our opinion, the first 1000 cubic feet at the regular rate is an ample quantity of water to provide for testing the sprinkler system,

TABLE 1

Water Rates, Kalamazoo, Mich.

Effective August 1, 1928

The rates charged for water shall consist of a "water charge" plus a "demand charge" as follows:

a. Water Charges‡

Schedule A:		
First 10,000 cubic feet per quarter	$ .10	per hundred
Over 10,000 cubic feet per quarter	.07½	per hundred
Schedule B:		
First 10,000 cubic feet per quarter	$ .10	per hundred
Next 90,000 cubic feet per quarter	.07½	per hundred
Over 100,000 cubic feet per quarter	.05	per hundred
Schedule C:		
First 1,000 cubic feet per quarter	$ .10	per hundred
Over 1,000 cubic feet per quarter	.30	per hundred

B. Demand Charges

All Schedules:

Meter Size, inches	*Quarterly Charge*
*⅝	$ 0.50†
⅝	0.80
¾	1.25
1	2.00
1½	3.50
2	6.00
3	11.00
4	20.00
6	40.00
*6 fire sprinkler	18.75†
*6 fire sprinkler	25.00
*8 fire sprinkler	33.00

* Applies to all meters measuring water to sprinkler systems.

† Old accounts only.

‡ A discount of 1 cent per 100 cubic feet is allowed on all bills paid before due.

Schedule A—Ordinary domestic and commercial accounts

Schedule B—Large "off peak" users only.

Schedule C—Fire sprinkler systems.

filling overhead tanks in connection with it and also to take care of any small reasonable leaks that might exist on the system. Then, we reasoned, if the customer insisted upon taking more water through

this detector meter, he should pay approximately three times as much, which he should otherwise because the meter registers about one-third of the water.

This rate schedule has worked like a charm. Whereas those customers who used large quantities of water through detector meters in the past could not account for their using these large quantities of water, the new rate schedules made it worth their while to find out why they were using large quantities of water and the use of these large quantities of water ceased.

For the information of the reader, the rate schedules are shown in table 1.

Earl E. Norman.[2]

[2] Superintendent, Division of water and Light, Department of Public Utilities, Kalamazoo, Mich.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Eliminating Unaccounted-for Flow and Leakage at Akron. H. LESTER NEWHALL. Eng. News-Rec., 100: 944, June 14, 1928. Unaccounted-for flow in Akron, O., has been reduced from 27 to 21.2 per cent since 1921, equivalent to reduction from 6.19 to 3.93 million gallons per day. During this period consumption increased from 15.01 to 18.82 million gallons per day. Two inspection crews, consisting of one experienced man and one laborer, equipped with Ford cars, cover city by districts. System is 100 per cent metered and all water is metered at pumps. Five years ago standard leakage test for acceptance of new mains was reduced from 200 to 100 gallons per inch-mile per twenty-four hours. Analysis of test reports covering 1927 construction shows average for all sizes and pressures from 100 to 250 pounds per square inch of less than 30 gallons per inch-mile.—*R. E. Thompson.*

Conserving Water Supply at Springfield, Mo. WM. J. GRAY. Eng. News-Rec., 101: 128, July 26, 1928. Owing to shortage of water in Springfield, Mo., it became necessary to institute measures for reduction of waste. Methods employed consisted in strengthening the whole water works organization, thorough reorganization of the meter department, and leakage surveys. Major result accomplished was to increase water sold through meters to 76.3 per cent, a gain of 53.1 per cent in four years. Per capita consumption was reduced from 77 gallons to 58 gallons. During this period income was steadily increased almost 20 per cent, while operating expenses were correspondingly reduced. Present supply is derived from 5 springs yielding average of 10 million gallons per day except during summer periods, in addition to which there are 3 deep wells having capacity of 3 million gallons per day. Purification plant consists of sedimentation basin, 8-million gallon filter, chlorinators and clear well. There is under construction (30 per cent completed) a 1250-million gallon impounding reservoir on North Sac River, formed by concrete gravity dam 45 feet high and 1200 feet long, at cost of $500,000.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Extension and Operation of Water-Distribution System of Springfield, Mass. Eng. News-Rec., 100: 1006–8, June 28, 1928. Maintenance and extension methods employed at Springfield described. System is under rather high (gravity) pressure, normally reaching 150 pounds per square inch in business and other lower parts of city, necessitating careful construction and prompt repairs. Pipe network includes about 265 miles of mains, laid uniformly 7½ feet from center line on north and east sides of streets. Valves are usually installed on street line so as to be easily located. There are more than 8200 gate valves, averaging more than 23 per mile of main. Details given of valve boxes. Each valve is operated at least once each year. Practically every one of 2400 fire hydrants has independent valve. All hydrants are of type designed not to leak even if hydrant post or valve is broken off at ground line. Separate 2½-inch sprinkler hydrants of post type are gradually being installed for use of street department. During winter months all hydrants are inspected at least twice a week and those in business district are inspected every two days to prevent freezing. All hydrants are placed in working order each fall. Smaller services are of cement-lined wrought iron pipe, while those above 2 inches are galvanized wrought iron or cast iron. Largest service permitted is 4 inches. Pipes are lined by the department. Connections to mains are made through bronze corporation cocks. At point inside curb a bronze curb cock is placed in service. Wrought-iron fittings are lined with lead at shop and great care is taken to prevent exposure of unprotected surfaces. Cement-lined services of this type were recently removed after fifty-two years and found in excellent condition. Galvanized iron services were employed for some time but discontinued owing to frequent blocking due to tuberculation. Method of cleaning such services described. All services are metered. Details included of emergency service and of organization in charge of distribution.—*R. E. Thompson.*

Capacity of European Turbines. John V. Zahlen. Eng. News-Rec., 100: 1017–8, June 28, 1928. Additional data.—*R. E. Thompson.*

Springfield Water Distribution Aided by Service Facilities. Eng. News-Rec., 100: 896–7, June 7, 1928. Brief illustrated description of well-equipped storage yard and service building at Springfield, Mass. Department lays all mains and services, sets valves, hydrants, and meters, and maintains all these by its own forces.—*R. E. Thompson.*

Court Refuses Damages in Water Supply Suit. Eng. News-Rec., 101: 126, July 26, 1928. In lawsuit for damages from city of Dover, N. H., on account of alleged "toxic gastritis" from drinking city water, verdict was in favor of city. Supply, from springs, is aërated, passed through slow sand filters, and chlorinated. Sample from service in question "indicated organically and bacterially excellent water, with freedom from turbidity and sediment, but with some odor."—*R. E. Thompson.*

Appraisal of Benefits of Water Supply for Youngstown and Niles. Eng. News-Rec., 101: 29, July 5, 1928. Benefits from works projected by Mahoning

Valley Sanitary District for new water supply of Youngstown and Niles, O., and division of benefits between the two cities have been determined by board of appraisers and its findings have been confirmed by court of jurisdiction. This action gives directors of district authority to finance project by levying assessments and issuing bonds. Details have been summarized by W. H. DITTOE, chief engineer of district, as follows: Appraisers set out total benefit of $5 per capita per year for twenty-five-year period, 1930–1955, corresponding approximately with period of payment of assessment upon the two cities. This per capita rate was applied to estimated total population for period mentioned, and actual annual benefit so calculated brought back to 1930 value, using interest rate of 4 per cent compounded, giving total benefit for period of $21,534,000. Estimated cost of execution of "official plan" is $9,150,000, exclusive of interest charges during construction. Total per capita benefit was made up of benefits of two kinds—specific benefit of $2.50 per capita per year and general benefit of same amount. Specific benefit is represented by actual monetary savings due to improved chemical quality of water, as follows: soap saving by reduction of hardness, 80 p.p.m., $0.58; saving in plumbing upkeep, $1.82 ($10 per dwelling per year); reduced depreciation of fabrics in laundry, saving of heat losses, etc., lumped at $0.10 per capita per year. General benefit, represented by improved conditions affecting public health, safety, comfort, convenience and welfare, encouraging general increase in property values, was fixed at $2.50 per year. Apportionment of total benefit to cities was arrived at as follows: Total benefit of $21,534,000 was divided into two parts termed, repectively, joint benefit and special benefit. All works and improvements for joint use were considered to confer joint benefit and all works for individual use of each city were considered to confer special benefit. Respective values of joint benefit and special benefit were determined to be in same ratio as estimated costs of works for joint and individual use respectively. Joint benefit was thus determined to be $14,337,300 and special benefit $7,196,700. Joint benefit was apportioned by using factors of population and tax valuation, giving equal weight to each of these factors. Special benefit to each city was apportioned by employing ratio of estimated costs of improvements provided for individual use of each city. Summation of benefits thus calculated showed Youngstown $19,499,100 and Niles $2,034,900, being 90.55 and 9.45 per cent of total benefit. Applied to estimated cost, tentative costs to Youngstown and Niles are $8,285,125 and $864,875 respectively. Appraisers recommended subsequent appraisals at 10-year intervals, beginning in 1930. To raise funds for construction, district will issue bonds not exceeding 90 per cent of amount of total assessment. Annual levies will be made, proportional to benefits, to meet yearly interest and bond redemption dues. Annual levy is to be paid by each city at tax collection periods and law permits city to collect for this purpose special tax levy exempted from statutory limitations. Interest on bonds during construction period is to be paid from proceeds of annual levies.—*R. E. Thompson.*

Power Pipe-Tapping Machine. Eng. News-Rec., **101**: 143, July 26. Brief illustrated description of machine developed in Detroit under direction of C. P. McGRATH for making 12- and 16-inch sleeve and valve cuts in large

water mains. A 28:1 gear reduction was designed to operate in conjunction with 2½-h.p. close-quarter air drill. Machine can be operated in ditch 25 inches wide. Formerly, hand operation required three to twelve hours and labor force of 6 to 10 men. Now one man in trench can make cuts on 12-inch and larger mains in twenty to sixty minutes.—*R. E. Thompson.*

Cause of Breaks in Cast Iron Water Mains Still Unsolved. Eng. News-Rec., 100: 1018, June 28, 1928. Brief details given regarding breaks in water mains (36-inch and 48-inch respectively) at Harrisburg, Pa., and Detroit, Mich., explanations for which have not been found.—*R. E. Thompson.*

Breaks in Water Mains at Cleveland and Cincinnati, Ohio. Eng. News-Rec., 101: 136, July 26, 1928. Cleveland. HOWELL WRIGHT. About 1 a.m. June 19, breaks occurred in 3 cast-iron bell and spigot mains in close proximity to excavation for new Cleveland Union Terminals. Breaks wrecked 12-inch gas main, tore up and twisted number of cables, ripped hole in street about 50 by 80 feet and washed about 2500 cubic yards of material into Union Terminal excavation. Mains were an 8-inch distribution main, 30-inch supply main, and 16-inch high-pressure fire line, each carrying pressure of about 60 pounds per square inch at time of breaks. Dates of laying were 1875, 1926, and 1906 respectively. Cincinnati. C. O. SHERRILL. Break in 36-inch cast-iron main laid in 1877 occurred on June 24, about 40 by 100 feet of granite street paving being torn up. Pipe thickness varied from $\frac{13}{16}$ to $\frac{1}{16}$ inches. There was practically no corrosion, original coating being in good condition both inside and out. No cause for break can be assigned.—*R. E. Thompson.*

Thames Flood Broke 265-Year Record. Eng. News-Rec., 100: 1005, June 28, 1928. Thames flood of January 6–7, 1928, in London, was higher by 11 inches than any flood for which records are available in period of 265 years. Extreme height was due to combination of circumstances—downcoming flood waters and what would naturally have been only a moderately high upcoming tide which was augmented by tidal bore caused by long-continued high winds that piled up water from north and south and drove it up Thames.—*R. E. Thompson.*

Court Holds City Responsible for Reservoir Failure. Eng. News-Rec., 101: 63, July 12, 1928. On December 23, 1918, extensive property damage resulted from flood in Boxley Canyon near Cedar Falls reservoir, constructed by city of Seattle, Wash., for municipal water supply and power purposes. North Bend Lumber Company sued city shortly after disaster, and series of suits have dragged on through intervening years to decision adverse to city recently handed down by State Supreme Court in Washington, sustaining verdict for $336,945.80 rendered by jury in Pierce County Court in 1927. Cedar River dam is concrete structure of gravity section, arched in plan, approximately 200 feet high in maximum section and having crest length of about 1000 feet. It is situated about 40 miles southeast of Seattle on Cedar River, about 1 mile west of point where river leaves Cedar Lake. Dam had not been completed but storage in reservoir had begun and water level had been raised

materially when flood occurred in Boxley Creek. Summit between Cedar and Boxley watersheds is glacial bench approximately 1 mile wide. Washout and slide on Boxley basin side of this summit was first visible evidence of flood that swept down stream. The lumber company claimed that impounded water, by seepage and percolation, passed through approximately 1 mile of glacial moraine on right bank and broke out at head of Boxley Creek, and contended that rising of water in Rattlesnake Lake below and to west of Cedar River was evidence that impounded water was source of trouble. City claimed that Rattlesnake Lake had history of rapid rises as far back as 1852; that breaking out of water occurred in north lateral moraine of Cedar River glacier; that north lateral moraine was connected directly with Cedar Lake, more than a mile from dam; that lake, before erection of dam, had risen to considerably higher elevation than at time of flood; and that there was an impervious stratum separating north lateral moraine from impounded waters of pool.—*R. E. Thompson.*

Chemical Handling and Control of the Baltimore Filters. James W. Armstrong. Eng. News-Rec., 101: 65–6, 1928. The methods of chemical control employed at the Montebello filter plants, Baltimore, are described. The new and old plants, of 128 and 112 million gallons capacity, respectively, adjoin each other. Alum is used as coagulant and is manufactured at the works from bauxite and H_2SO_4. The process employed is outlined and the automatic apparatus used for controlling the application of the resulting alum solution to the water is described. Lime is added to the filtered water to reduce CO_2 and prevent corrosion, the amount required being determined by the pH value of the water. The control apparatus is similar to that employed for the alum. —*R. E. Thompson (Courtesy Chem. Abst.).*

Key West Prospecting for Public Water Supply. Eng. News-Rec., 101: 86, July 19, 1928. Key West, Fla., which is probably largest city in United States without a water works system, will endeavour to develop supply from artesian wells. If this fails, it is proposed to go 120 miles to mainland. At present rain water collected in cisterns is used for drinking purposes; surface wells, for bathing and closet flushing; and salt water from "well hydrants," for fire protection. Latter consist of wells drilled with rotary drill to depth of 60 feet, fitted with pipes and hydrants. Supply thus provided is unlimited. Distribution system will be constructed and sewerage and sewage disposal system installed. Proposed supply will be developed by Munroe Water Supply District. Population of Key West in 1925 was 19,945.—*R. E. Thompson.*

Spillway Capacity That Should Be Provided for Dams. Eng. News-Rec., 100: 1018, June 28, 1928. Runoffs computed by formulas of Kuichling, United States Geological Survey, and Fanning are compared graphically with actual runoffs as observed along Winooski River during flood of 1927. From data it would appear the part of wisdom to design spillways of important dams, especially those constructed of earth, to safely pass floods corresponding in severity to those upon which Kuichling's formula No. 2 are based.—*R. E. Thompson.*

Eliminating Phenolic Tastes from Drinking Waters. Eng. News-Rec., **101**: 95, July 19, 1928. Article entitled "Sewage Treatment in the Light of European Practice," by GEO. B. GASCOIGNE, contains following discussion of phenolic waste pollution. Quenching plants are still in use for destroying phenols and tar acids. This process is exceedingly costly, both as regards installation and operation, and is not dependable. In Europe, sewage works of oxidation type have handled satisfactorily wastes of this character which did not exceed 2 per cent of domestic sewage flow. This has led to installation of equalizing tanks at point of origin for releasing wastes into sewer system at uniform rate. Recovery of phenol by absorption with benzol has been practised recently at Domestic Coke Corporation, Fairmont, W. Va. Revenue varies somewhat and appears to meet operating costs, but not capital charges. Attempt is being made in England to develop equipment and process changes in coking of coal and production of gas which will eliminate these objectionable wastes. At Mansfeld, Ger., IMHOFF has installed treatment works where wastes, separate from domestic sewage, with 2000 p.p.m. phenols, are first treated in cinder filters. Effluent is then mixed with domestic sewage in ratio of 2 to 5, mixture being given colloidal treatment by contact aërators. Real solution of problem lies in removal or absorption of these wastes during process of water purification. Some progress has already been made in Europe toward producing an absorptive in water purification.—*R. E. Thompson.*

Filter Plant Provides Public Square and Bath Houses. PAUL HANSEN. Eng. News-Rec., **101**: 87–8, 1928. An illustrated description of the new water purification plant at Kenilworth, Ill., on Lake Michigan, which replaces the old pressure filters which did not at all times effect satisfactory removal of turbidity. The plant, which has a nominal capacity of 1 million gallons per day, consists of mixing and coagulation basins, 2 filters, and clear well. Provision was made for a thirty-minute mixing period to facilitate removal of microörganisms which occur in the lake water in certain seasons. The population is 2500.—*R. E. Thompson (Courtesy Chem. Abst.).*

Alloy Prolongs Life of Waterwheel Nozzles. Eng. News-Rec., **101**: 88, July 19, 1928. At Balch plant of San Joaquin Light and Power Corporation the water passes through 7½-inch nozzles of 40,000-h.p. double overhung waterwheel at velocity of 360 feet per second, being delivered under effective head of 2243 feet. Although water is very clean and free of abrasive material, velocity has highly erosive effect on throat rings and nozzles, bronze or cast-steel parts being worn out and requiring replacement in thirty-five or forty days. Stellite, welded on with acetylene torch as surface finish, shows no sign of wear after two to six months service. Surface of stellite was ground smooth on emery wheel, being too hard to be worked with cutting tool in lathe.—*R. E. Thompson.*

Record Runoff from Black River Watershed, New York. EDWIN S. CULLINGS. Eng. News-Rec., **101**: 98–100, July 19, 1928. Recent flood on Black River, due almost entirely to melting snow, reached maximum of 33,900 second-feet at Watertown gaging station on April 9, 1928. This flow has been exceeded

only twice within known history of river. Calculation of storage in reservoirs shows that actual runoff was materially larger than recorded peak of flood and it is evident that, had it not been for storage reservoirs on headwaters of some of smaller tributaries, flow of record height would have resulted. These reservoirs control somewhat less than 15 per cent of watershed and they reduced flood flow in lower river by nearly 16 per cent.—*R. E. Thompson.*

Fabricating and Laying New Pipe for Springfield's Water Supply. Eng. News-Rec., 101: 101–2, July 19, 1928. Details given of 6-mile pipeline being constructed between Provo Mountain Reservoir of Springfield, Mass., water supply system and the Connecticut River. Pipe, in 48- and 54-inch diameters, is being laid in 30-foot lengths shop-fabricated by arc-welding together two semicircular sections of steel plate. Circumferential joints between sections are riveted in field. Total weight of pipe is about 4500 tons. Each pipe section is required to undergo hydraulic test of 333 pounds per square inch at shop. Before leaving shop, sections are double-dipped in coal tar pitch varnish at temperature of about 310°F.—*R. E. Thompson.*

Determination of Excess of Alkali in Hypochlorite Solutions. A. Wachter. J. Am. Chem. Soc., 49: 791–2, 1927. From Chem. Abst., 22: 740, March 10, 1928. Add excess of nickel hydrate suspension, heat to boiling, filter, wash precipitate and titrate with standard hydrochloric acid. Treatment with nickel hydrate removes hypochlorite without changing acidity of solution, excess nickel hydrate being filtered off.—*R. E. Thompson.*

Sodium Aluminate as a Coagulant in Chemical Treatment of Cannery Waste Waters. J. A. Holmes and G. J. Fink. Ind. Eng. Chem., 21: 150–1, (1929). The waste consisted of the liquid discharged from the cyclone filler and wash water from tables and floor. It had an acidity varying from 18 to 260 p.p.m. The total volume was about 50,000 gallons per sixteen-hour day. Storm water entered this sewer thereby increasing dilution. The waste is screened, sodium aluminate and lime added, approximately 1 pound lime and 0.16 pound sodium aluminate per gallon of waste, with mechanical agitation, which treatment produces a floc and also maintains a pH of 10+; it is then passed to a round-the-end baffled mixing basin, allowed to settle, and the effluent discharged into an open ditch. The raw waste has an oxygen consuming value of 2100 p.p.m., the effluent, of only 396 p.p.m., or a reduction of 81 per cent. This value corresponds to that found in the city storm water sewage and is satisfactory to the officials. Cost is about $35.00 per million gallons of waste.—*Edward S. Hopkins.*

Factors Contributing to Quality of Public Water Supplies. H. E. Jordan. Ind. Eng. Chem., 21: 152–6, 1929. A general review of existing conditions and standards, in which rating values are given to the safety, taste, chemical balance (industrial and corrosive characteristics), appearance, and temperature of a supply. Assignment of this value in terms of percentage is: safety, 51; taste, 22; chemical balance, 20; appearance, 5; temperature, 2; thereby making plain that "safe water is the first factor in quality, but only one of several."—*Edward S. Hopkins.*

Superchlorination and Subsequent Dechlorination over Carbon of Water for Municipal Supply. Ernst Watzl. Ind. Eng. Chem., 20: 156–8, 1929. This article describes the use of charcoal beds to remove residual chlorine from water. It is also thought that such a bed will remove phenol compounds in conjunction with chlorine, either by adsorption in the bed or by oxidation with the chlorine present. Only granular charcoal with high adsorptive qualities is suitable. Research is being undertaken upon the use of charcoal beds, using a plant of 300,000 gallon capacity in Cleveland.—*Edward S. Hopkins.*

Physical Characteristics of Water; Transparency and Colour. A. Guillerd. Ann. d'Hyg., Pub. Indust. et Sociale, 4: 449–96, 1928. From Bull. Hyg., 3: 1020, December, 1928. A full and illustrated account of various forms of apparatus devised for getting a numerical measure of the turbidity and color of water.—*Arthur P. Miller.*

The Filtration and Treatment of Water for Domestic Purposes. A. C. Houston and H. E. Stilgoe. Surveyor, 73: 625–6, 1928. From Bull. Hyg., 3: 1021–1022. December, 1928. Just a century has passed since Simpson constructed the first slow sand filter at Walton, England. This system has been widely used. As it was studied, improvements were made, e.g. recognition of beneficial results from settlement and storage. Storage has, however, the disadvantage of permitting algal growths to develop in the reservoirs. These can usually be controlled by the use of copper sulphate. Unstored, or stored but unfiltered water, passing through pipes sometimes supports the growth of mussels which will cut down the effective diameter of the pipe. One drawback of slow sand filters is that algal growths may reduce the normal run of two to three months to a week or less. With a highly colored water, rapid filters preceeded by coagulation are advantageous. At the new Walton works, mechanical filters are used for primary treatment and are followed by slow sand treatment. The average quantity of water handled by the slow sand units in 1927 was 445 m.g. per acre cleaned. Further description of the details of these filters is given. The raw water used showed *B. coli* in 1 cc. in 82.9 per cent of the samples, while the filtered water after chlorination gave no *B. coli* in 100 cc.—*Arthur P. Miller.*

Effect of Chlorine in Drinking Water. Use of α-Naphthoflavone as an Indicator for Free Chlorine. M. Hahn, F. Schutz, and S. Pavlides. Ztschr. f. Hyg. u. Infektionskr., 108: 439–73, 1928. From Bull. Hyg., 3: 1022. December, 1928. The writers consider the dose of chlorine necessary to sterilize a water, the most desirable period of contract, and a suitable test by which operators can determine the chlorine dosage. When estimating chlorine by the amount of iodine set free from hydriodic acid, α-naphthoflavone has been found to be twice as sensitive as starch and hence preferable. The conclusions as to the dosage, the amount of free chlorine in the water after five minutes reaction, and the contact period needed to give the full sterilizing effect are in general agreement with current British and American practice.—*Arthur P. Miller.*

Lead Poisoning from Lead Piped Water Supplies. W. Wright, C. O. Sappington and Eleanor Rantoul. J. Indust. Hyg., 10: 234–52, 1928. From Bull. Hyg., 3: 1025–1026. December, 1928. A case of lead poisoning, not of industrial origin, led to the medical examination of 253 persons in Massachusetts. Signs of poisoning, moderate or slight, were found in 63 of these. All waters tested contained lead coming from lead pipes; the amount seeming to be related to the CO_2 content of the water rather than to the length of the pipe. As little as 0.1 mgm. of lead ingested daily over eight and one-quarter years caused poisoning.—*Arthur P. Miller.*

Angoulême Water; Causes of its Pollution and Effect on Incidence of Typhoid. Three Examples of Purification by Javellization. A. L. Capdevielle Arch. Med. et Pharm. Milit., 88: 919–37, 1928. From Bull. Hyg., 3: 1027–1028. December, 1928. Angoulême had much typhoid fever up to 1889. From then on to 1927 there were a number of epidemics. The outbreak in 1908 had the characteristics of a water-borne one. For six years following the war, the disease was latent in the civil population, and in 1927 there occurred another epidemic extending from about December, 1926 to August, 1927. The garrison at this point escaped until February, 1927, when the first case occurred. The military combated the impure water by introducing "javel" as did also the civil authorities. Water treated in this way gave satisfactory protection.—*Arthur P. Miller.*

Paranasal Sinus Infection and Swimming. F. E. Hasty. J. Amer. Med. Ass., 89: 507–8, 1927. From Bull. Hyg., 3: 1029, December, 1928. The writer shows the danger of infecting paranasal sinuses by swimming in contaminated water. If drinking water standards are to be applied to swimming pool water, more attention should be given to types of bacteria than to their numbers. A test to demonstrate how water reaches different parts of the nose is described. One person in the *Discussion* brings out that there was an increase in middle ear abscesses in this city coincident with the starting of a swimming pool and that the number of abscesses dropped as soon as the pool water was kept clean. —*Arthur P. Miller.*

Swimming Baths: the Dangers of Pollution and the Measures for Prevention. J. G. Forbes. J. State Med. 35: 595–607, 1927. From Bull. Hyg., 3: 1030–1031, December, 1928. Of the 100 public baths under the control of metropolitan boroughs, 40 are provided with filters and 60 operate on the fill-and-draw plan. Tests of swimming bath waters are made by the Ministry of Health and the London County Council working jointly. Bacteriological examinations showing a count of 4,000 per cubic centimeter indicate the presence of organisms derived from (1) skin contamination; (2) normal saliva; and (3) faecal contamination. These organisms under certain conditions may prove pathogenic. The author brings out that salt water is not free from bacteria; that infected towels are a source of danger; and that maximum bactericidal effect of chlorine is during first six hours; following which, residual chlorine is insufficient to inhibit bacterial growth, bacterial increase starting when chlorine residual reaches 0.1 to 0.2 p.p.m. The bacteriological criteria of the

American Public Health Association swimming pool standards are quoted.—*Arthur P. Miller.*

A Swimming Bath with Waves at the Lunapark, Berlin. Gesundheits-Ingenieur, 50: 831, 1927. From Bull. Hyg., 3: 1032. December, 1928. A new pool of this type in Berlin has wave producing machinery capable of making waves of different heights (up to 1 meter) and velocities. The water is purified and chlorinated and kept at about 72°F. The glass roof can be moved so as to open the pool to the sky.—*Arthur P. Miller.*

The Bacterial Examination of Water in Public Swimming Baths. G. K. Bowes. J. State Med., 36: 521–45, 1928. From Bull. Hyg., 3: 1033, December, 1928. Swimming bath pollution is of two kinds, organic and bacterial, the former serving as a culture medium for the latter. Examination of water samples from both fill-and-draw and recirculating pools, shows that the second method is more effective in keeping water free from bacteria. A drinking water standard can be maintained in swimming pools by continuous chlorination with the proper residual of 0.2 to 0.5 p.p.m.—*Arthur P. Miller.*

Public Bathing Places. Bordas and Neveu. Compt. Rend. Acad. Sci., 187: 485–6, 1928. From Bull. Hyg., 3: 1033, December, 1928. Some of the bathing pools in Paris which are filled with water from the Seine or Marne Rivers are visited daily by from twelve to fourteen hundred persons who bathe in the 700 cubic meters of water. The pool water is supposed to be changed every eight days. Bathers are not required to take a bath first; no control is exercised. Laboratory tests of this water do not make the proper impression on the lay mind and the authors suggest that 5 litres of liquid be pressure-filtered through white flannel so that the amount of dirt can be seen and evaluated. Measures to prevent contamination can then be taken. [The abstractor does not see why any tests should be necessary. It is obvious at once that the pool load is too great.]—*Arthur P. Miller.*

Paints for the Pool. C. P. McCord. Hygieia, 6: 485–6, 1928. From Bull. Hyg., 3: 1033, December, 1928. Certain paints absorb chlorine so as to make it difficult to obtain a residual in a swimming pool the walls of which have been painted with such chlorine-absorbing paints. White lead in linseed oil does not, but it gets dingy; white tile lining is satisfactory, but expensive. A cement rich in powdered white marble is probably best of all.—*Arthur P. Miller.*

Iodine Deficiency in Water as an Index of Goiter. D. F. Smiley. Amer. J. Hyg., 8, 297–8, 1928. From Bull. Hyg., 4: 62, January, 1929. The places of residence of 967 students going to college with enlarged thyroid glands were looked up on a map which gives the regions where the waters contain respectively more and less than 22 parts of iodine in 100 billions. Of this number, 67 per cent were found to come from districts in which the water contained the smaller amount. Of the same number of students with normal thyroids, 57 per cent came from districts in which the water contained the smaller amount also. It is concluded that the iodine content of the water in a district is not an accurate index of the liability to thyroid enlargement.—*Arthur P. Miller.*

Biochemical Oxidation of Phenolic Wastes. F. W. Mohlman. Amer. Jour. Public Health, 19: 2, February, 1929. This comprehensive and original paper upon studies conducted by the Sanitary District of Chicago in the treatment of sewage containing various quantities of ammonia still liquors, or phenolic wastes, upon experimental sand filters cannot be readily abstracted due to the large amount of quantitative data. In general it was found that the presence of as little as 0.1 per cent of phenolic wastes resulted in a marked increase in the apparent sewage concentration as measured by the five-day B.O.D. The application of sewage to sand filters with 3-foot depths of sand indicated that the presence of 0.1 per cent phenolic wastes in the applied sewage did not appreciably affect the quality of the effluent. With 2.0 per cent phenolic wastes in the applied sewage, however, the effluent was of an inferior quality. The treatment of sewage containing 1 per cent or less of phenolic wastes upon intermittent sand filters is feasible and such treatment leads to the removal of 90 per cent of the phenol present in the influent. No experiments were made with the treatment of sewage containing phenolic wastes by the activated sludge process. The experiments at Milwaukee and at Waldenburg, Germany, indicated, however, that this process is able to treat sewage containing 30 to 40 p.p.m. of phenol with complete removal of the phenol. The increase in air consumption or aëration period required has not been conclusively determined. Considerable space is devoted to the nature of the oxidation of phenolic wastes in sewage. Anaerobic decomposition of sewage containing phenolic wastes in two gallon bottles resulted in a reduction of phenolic content of 250 to 14 p.p.m. after 138 days digestion at room temperature, although no appreciable reduction occurred in short periods of time. Data were quoted indicating that the spores of anaërobic organisms are not killed by concentrations less than 5 per cent of phenol although aërobic spore formers are much more sensitive and are killed by concentrations in excess of 0.5 per cent, which was likewise the case with non-spore forming aërobes. This confirms the fact that large concentrations of phenol are required before anaërobic sludge digestion is inhibited. It was determined that the aëration in bottles of sewage containing ammonia still phenolic wastes, when seeded with 10 per cent of previously aërated mixtures, led to a very pronounced reduction in the phenolic content as compared with similar treatment of unseeded material. Data also are given to indicate the great importance of temperature and of agitation because at 37°C. the phenolic content of such mixtures was reduced in four days to about one-tenth the original concentration, whereas at 20°C. about one-fifth of the original concentration remained at the end of eight days. Similar results were secured by the biochemical oxidation of phenolic wastes mixed with polluted river water. A *discussion* of this paper by Wm. A. Ryan, Sanitary Chemist of the Department of Public Works, Rochester, N. Y. reviews the work conducted jointly by the City of Rochester and the Rochester Gas and Electric Corporation relative to treatment of sewage containing phenolic wastes in Imhoff tanks. These experiments indicated that phenolic wastes did not affect character of sludge except for the gradual increase in phenolic content to a maximum of 12 p.p.m. There are indications that the addition of small amounts of phenol to settled sewage helped rather than harmed the digestion of sludge. Indications are, therefore, that Imhoff tanks will adequately treat

sewage containing phenols when ratio of phenols to sewage is less than 1 to 166. —*Chas. R. Cox.*

The Operation of a Well Organized Meter Department. C. J. Eld and J. J. Rost. American City, 15: 3, 117–121, March, 1929. This is a complete account of the operation of the well organized meter department of the South Pittsburgh Water Company, embracing the installation, reading, and repair of meters, under the so-called meter superintendent. The meters are read by men capable of making minor repairs or of replacing meters in need of repair with new or rebuilt meters. Thirty-four thousand meters are in use by this one company, and in order that the work of maintenance may be expedited, an elaborate record system has been developed. In general this article illustrates the value and economy of a well organized meter service department. *Chas. R. Cox.*

Manila's New Water Supply. H. W. Wilkins. American City, 15: 3, 135–139, March, 1929. This article gives a complete historical sketch of the water supply of the city of Manila. The population is 325,000, but there are only about 21,000 services. The estimated consumption is about 20 million gallons per day. The new plans for water supply system embrace the construction of a large impounding earthen dam and a conduit with a capacity of 80 million gallons per day. A modern mechanical filtration plant is likewise being constructed with a capacity of 40 million gallons per day, with provisions for enlargement to a maximum capacity of 80 million gallons per day. The plant will be placed in charge of a competent bacteriologist. When additional water is needed, the Angat project will be constructed which will furnish water from a separate watershed through a separate future aqueduct.—*Chas. R. Cox.*

Methods of Estimating Pollution in Tidal Estuaries and Water Reservoirs. D. Ellis. Official Circular British Water Works Association, 69, October, 1927. Bulletin of Hygiene, 3: 5, 430, May, 1928. The author stresses the importance of biological tests to obtain accurate information as to the amount of organic matter in polluted water. These tests deal more directly with the kind of information required and, in cases of small pollution, are more delicate than the customary chemical tests.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Determining the Sanitary Quality of a Water Supply. Jane H. Rider. Bulletin Arizona State Board of Health, 17, July, 1928. The author makes a very significant statement in saying: "The quality of the water cannot be determined definitely from laboratory analysis alone. The sanitary conditions of the source and the surroundings must be investigated by a trained observer before a complete report can be made." A paragraph is devoted to interesting discussion of the significance of the fecal and non-fecal types of the *B. aerogenes* group, and it is pointed out that although we are concerned primarily with the presence of *B. coli*, the presence of *B. aerogenes* in a deep well supply would indicate the entrance of surface water into the supply. Con-

versely, the presence of *B. aerogenes* in a surface supply known to be free of fecal contamination would be without significance. In a summary the author states: "definite value may be assigned to the fecal and non-fecal members of the coli-aerogenes group only when complete data concerning the supply is available."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Bacterial Pollution of Bathing Beach Waters in New Haven Harbor. C.-E A. WINSLOW and DAVID MOXON. American Journal of Hygiene, 8: 3, 299, May, 1928. A study was made of the pollution of water in the New Haven harbor at bathing beaches. Eleven sampling stations were established on the West shore, three in the Quinnipiac River and sixteen on the East shore. Samples were collected at each harbor station on eleven different days in the period from November, 1926, to April, 1927. There is a sketch of the harbor showing location of the sampling points. The direction of the wind is given as the chief factor in the pollution of those bathing beach waters. Among the conclusions drawn are that the bathing beach waters of New Haven Harbor are highly polluted and at certain points are so heavily polluted as to be manifestly unfit for bathing. A comparison is made in this article between the results of this study and the limits set by the Association of State Sanitary Engineers and the standard generally accepted in the State of California.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Epidemic of Cholera in Hinghwa City, Fukien, September 1–25, 1927. M. K. YUE. China Med. Jour., 42: 3, 151, March, 1928. Tropical Diseases Bulletin, 25: 9, 677, September, 1928. "One cholera epidemic is much like another, but this short paper is interesting and well written. The author describes the city of Hinghwa, with its gates and fine circular wall 4 miles long. It contains 40,000 inhabitants. All wells are supplied by surface and subsoil water and grossly polluted. The large number of leaking latrines and their close proximity to the wells is staggering. Rogers' saline treatment and 'Tomb's Mixture' were used and sanitary measures were adopted."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

The Protection of Water Supplies. F. M. VEATCH. Bulletin Arizona State Board of Health, 13, July, 1928. "This article is rich in suggestions for the guidance of the water works investigator and water works operator and is deserving of close reading. The author concludes the article as follows: It seems, therefore that the proper program for protecting all water supplies regardless of the source, is about as follows: (1) determine the safety of the water by a sufficient number of bacteriological and chemical tests, and a careful sanitary survey; (2) if the water is not fit for chlorination as regards turbidity or other pollution, give it the required treatment; (3) sterilize the water continuously; (4) make routine tests to determine the effect of sterilization."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Surface Pollution of the Water Supply at the United States Naval Station, Tutuila, Samoa. J. R. PHELPS. United States Naval Medical Bulletin, 26: 3, 742, July, 1928. The source is rain water collected on a watershed lo-

cated in the nearby mountains. From the water-shed the water finds its way rapidly into the upper reservoir which is 813 feet above sea level and has a capacity of 1,720,000 gallons. The water in the reservoir is usually very turbid to muddy. From the upper reservoir the water is delivered by an iron pipe to a hydroelectric plant near which are located two small distribution reservoirs. Water can be passed to service separately from either of these reservoirs and likewise to waste in the ravine. The front reservoir can be filled either from the hydroelectric plant or the back plant. The back reservoir is fed by two small streams, which bring in water from a comparatively low habitated area and is liable to human contamination. Water from the back reservoir leaks through to the front reservoir.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Municipal Work in Stafford. W. Plant. Surveyor, 73: 1893, 481, May 4, 1928. *Water Supply.* The water supply of Stafford is derived from a well 114 feet deep. The total consumption of water during year ending March, 1928, was 309,355,000 gallons or 26.83 gallons per capita per day based on population supplied of 31,500. The cost of operation during the year was 1.285 d. per 1000 gallons. A 1-million gallon concrete reservoir is under construction at cost of £9,000.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Diarrhea and Enteritis in Porto Rico, II. Relation to Water Supplies. Earle B. Phelps and Jorge Victor Davila. Porto Rico Review of Public Health and Tropical Medicine, 3: 11, 468, May, 1928. The distribution of diarrhea and enteritis deaths among urban and rural sections, with and without water supplies, to determine the relations between water supplies and death rates was studied. Communities were carefully grouped and the age groups of 0 to 1 year and 1 to 5 years studied. By certain computations making allowances for deaths from other causes, etc., it was concluded that in the age group 1 to 5 years the indications are that there is an excess of diarrhea and enteritis deaths among urban and rural communities having water supplies over those having no public water supply. The studies in the other age group were unsatisfactory. It is the sense of the article from a statistical view point that diarrhea and enteritis over one year of age as reported is probably largely water-borne.—*A. W. Blohm* (*U. S. H. P. Eng. Abstracts*).

Rural Water Supplies. F. W. Macaulay. Surveyor, 74: 1906, 97, August 3, 1928. Although a large majority of inhabitants of England and Wales live in urban communities where provision is made against water shortage through public piped supplies, a considerable proportion live in rural villages, where the water situation is less satisfactory. A fair and growing proportion of these villages have piped water supplies, but in many cases at least one-third of the houses are not connected to such supplies and in some instances the sanitary quality of water thus furnished is not satisfactory. In many communities having no piped supplies, water famine exists in dry summers. To remedy these difficulties, it is suggested that regional water committees be formed, with authority to study the needs of their local communities and recommend measures of relief.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Some Information Concerning a Quickened Slow Sand Filtration in the Tropics. K. HOLWERDA. Mededeelingen Van Den Dienst Der Volksgezondheid in Nederlandsch Indie, 17: Part II, Foreign Edition, 383, 1928. "Slow sand filter rates of about 10 cm. per hour (2,600,000 gallons per acre per day) appear to have been the established custom in the past in the Netherlands Indies. Experiments were conducted to determine whether a greater rate would not be advisable in definite cases and to compare the bacteriological results of filter rates at 10 cm. per hour with higher rates for installations in the Netherlands Indies. The experimental set-up consisted in preliminary coagulation and sedimentation of the water from Tji Liwong, preliminary filtration through sand of 0.5 mm. later changed to coarse gravel and secondary filtration through sand of 0.2 mm. The results indicated that with a filter rate of 30 cm. per hour (7,800,000 gallons per acre per day), with a well ripened filter, a considerable improvement in the water could be obtained so that its application in combination with chlorination seemed worthy of recommendation in many cases, especially where the raw water was of fair sanitary quality. If, however, coagulation is necessary in improving the water for higher rates of slow sand filtration, the use of quick (mechanical) filters seemed preferable. It remains to be ascertained how far slow sand filters either with or without increased rates of filtration are satisfactory for the different waters of the Netherlands Indies and to what extent it will be possible to increase the rates in definite cases."—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Some Notes on the Biology of Raw Water Reservoirs. M. F. TRICE. Jour. North Carolina Section Amer. Water Works Assn., Proceedings of Seventh Annual Meeting, 5: 1, 127. The author of this article describes rather comprehensively the cycle by which the flora and fauna of ponds and reservoirs are produced and the relation of such aquatic microscopic life to problems of taste and odor. Graphical representation of this cycle is also given. A very interesting article particularly for plankton students.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Progress Report on Canning Waste Treatment Studies. Conducted by the Ohio Canners Association and the Association of New York State Canners, Inc., under the supervision of A. Elliott Kimberly, Consulting Sanitary Engineer. This report covers the experiments made at Canal Winchester, Ohio, from August 24, 1926, to October 8, 1926, on the treatment of wastes from corn, succotash and lima bean packs, and the experiments made at Albion, N. Y. between August 9 and October 25, 1927, on the treatment of wastes from green bean and tomato packs. **Canal Winchester Experiments.** Treatment studies covered screening with fine mesh screens chemical precipitation, chlorine sterilization and oxidation of the screened wastes, at high rates, on lath and crushed lime filters and on sand filters.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Sanitation of Bathing Beaches. WARREN J. SCOTT. Connecticut Health Bulletin, 42: 8, 166, August, 1928. This article discusses the sanitation of bathing beaches and especially the salt water beaches of Connecticut. Refer-

ence is made to the standards proposed for swimming pools and other public bathing places by the joint committee of the American Public Health Association and the Conference of State Sanitary Engineers. It is noted that very little of the report deals with bathing in natural streams, lakes and tidal waters. This joint committee report however reads: "It is very desirable that the bathing water at public bathing places on natural streams, lakes and tidal water should be of the same standard of bacterial quality as is required for swimming pools." Theoretically there can be no objection to this statement, but it is considered practically impossible to comply with such a standard at most of the salt water beaches during the height of the bathing season. The importance of considering sanitary surveys along with the standards is brought out and also the necessity of reducing the pollution of bathing areas by means of properly operated sewage treatment plants.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Disinfection of Swimming Baths in the Tropics with Chlorine and Chloramin. K. Holwerda. Mededeelingen Van Den Dienst Der Volksgezondheid in Nederlandsch-Indie, 17: Part II, Foreign Edition, 357, 1928. Experiments on the chlorination of the water, with chlorine gas, hypochlorite and chloramin, in two open air swimming pools of the tropics in the municipality of Batavia are cited. Owing to the strong catalytic action of sunlight in decomposing hypochlorite it was found impossible to keep a fixed minimum residual chlorine in the water of swimming pools with tropical conditions. Disinfection with hypochlorite could however be obtained by distribution at the inlet, at the middle of the tank and at the outlet; and the adjustment of the amount added, 6 mgm. per liter during the day and 2 mgm. per liter during the night. The decomposition in sunlight of chloramin was much less but because of its weaker disinfecting power a sufficiently great minimum quantity of chloramin was needed. In practice, in Batavia good results were obtained with a residual content of 0.4 mgm. per liter of active chlorine as NH_2Cl. Bacteriologically, disinfection with chloramin appeared to give better results.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Thinking South African in Engineering. T. G. Caink. Surveyor, 74: 1909, 161. August 24, 1928. This paper, presented at the annual meeting of the African District of the Institution of Municipal and County Engineers, calls attention to fundamentally different conditions from those pertaining in Europe and America, that must be considered in providing engineering works in South Africa. The daily consumption rate of 100 gallons or over per capita is generally higher than in Europe, where 25 to 30 gallons is ample. Where these greater requirements are not provided for, serious consequences result during the hot, dry seasons. Increased costs for purification plants are therefore necessary since dual supplies are not practicable. Conservation or storage is generally necessary, as in South Africa droughts of twelve months' duration are not infrequent.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Municipal Works of King William's Town, South Africa. H. M. Tait. Surveyor, 74: 1909, 163, August 24, 1928. Water supply, sewerage, trades waste disposal and electric power production for this city of 10,000 population are described. The water supply is largely an impounded one and, due to increased consumption was extended in 1910. Considerable trouble has been encountered with crenothrix in the cast-iron supply mains; the incrustation in the steel pipe is almost negligible. The per diem consumption is 550,000 gallons.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Oil Pollution. C. H. Roberts. Conseil Permanent Int. Explor. Mer. J. Conseil 1, 245–75 (1926); Boil. Abstracts 1, 790. Chemical Abstracts, 22: 16, 3008, August 20, 1928. "Gas oil, Diesel oil, 600 seconds oil and 1500 seconds oil were used in the experiments. These oils represent the four types most commonly used at sea. It was found that (1) oil films slow down absorption of 0 from air, but in very thin films, likely to be met with at sea, the slowing down was not appreciable. (2) Agitation, such as would be met with at sea, markedly increases the rate of absorption through an oil film. (3) A simple method is suggested for checking spread of oil fuel in restricted waters. (4) All the oils tested were found to be toxic to fish; this is believed to be due to soluble toxic substances and to emulsions. (5) On exposure to air, extracts of gas oil and Diesel oil lose much of their toxicity. An extract of 600 seconds oil was unaffected by exposure but an extract of 1500 seconds oil was more toxic. (6) Oil films do not prevent the growth of fresh water plants."—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

River Pollution. Anon. Surveyor, 74: 1922, 461, November 23, 1928. The present method of dealing with the problem of river pollution is inconsistent and of a piece-meal nature, e.g. certain measures are enforced in one area while uncontrolled pollution is going on elsewhere on the same watershed. Dr. Ardern suggests the creation of catchment area boards. These boards should be elective bodies representative of all interests concerned. They should be more or less independent of state assistance and control, and should have statutory power to levy the cost of their undertakings on the parties concerned. The advantages claimed for this method of treatment of the river pollution problem are: (1) uniform treatment of the subject throughout the country; (2) coördination of effort in dealing with the pollution of any river, leading to economy in expediture; (3) centralization or decentralization of treatment plants n any one area would be decided on the merits of the plan; (4) reconstruction of water courses in certain areas might result in land reclamation, as well as in improvement of river conditions; (5) the reproach in regard to sanitary conditions on certain rivers would gradually be reduced to a minimum; (6) the question of pollution by trade wastes could be dealt with more satisfactorily, and certainly better controlled.—*A. W. Blohm* (*Courtesy U. S. P. H. Eng. Abstracts*).

Simplified Procedure for Measuring the Index of Water Pollution. Charles Gaussen. Compt. Rend. Soc. Biol., 98, 1405–8 (1928). Chemical Abstracts, 22: 16, 3007, August 20, 1928. "The test medium was prepared by the addi-

tion of 30 parts of peptone (Poulenc, free from indole) and 5.0 parts of NaCl to 1000 of water. After boiling and filtering the solution, one drop of saturated 95 per cent alcoholic solution of toluidine blue was added and the mixture sterilized at 115° for twenty minutes. The medium thus prepared was distributed in tubes and flasks to which is then added the water to be tested in amounts from 1 drop to 100 cc. and the mixtures are kept at 37° for thirty-six to forty-eight hours. From the color developed the number of *B. coli* per unit volume of water is estimated.—*A. W. Blohm (Courtesy U. S. P. H Eng. Abstracts).*

Report of the Water Softening and Purification Works for 1927, Columbus, Ohio. The City Bull., Columbus, O. Ann. Report 1927, 27–35; cf. C. A. 22, 1816. Chemical Abstracts, 22: 17, 3246, September 10, 1928. "The per capita consumption of water was 9.8 gallons per day. Hardness was reduced from 230 p.p.m. to 87. The cost of CaO, soda lime and Cl per million gallons treated was $14. Carbonation effectively reduced the phenol alkalinity from 33 p.p.m. to 7. The only difficulty in operating the carbonation plant was due to the corrosive action of the gases on the valve seats of the air compressor used to force the washed gases through the diffusers. Full details are found in 12 tables."—*A. W. Blohm (Courtesy U. S.P. H. Eng. Abstracts).*

Some Unusual Methods in Purification. MARTIN E. FLENTJE. Water Works Engineering, 81: 25, 1725 and 1747, December 5, 1929. The New Rochelle, N. Y., plant encountered considerable trouble with cyclops and daphnia. Copper sulfate in doses up to 10 pounds per million gallons was ineffective in destroying them. 1.75 p.p.m. of chlorine did not kill them in one hour but killed them in 12 hours. 3.50 p.p.m. of chlorine killed them in thirty minutes. Sodium thiosulfate mixed with soda ash was used for de-chlorination. Soda ash and lime were used to provide alkalinity for the alum reaction; but during August, September and October these chemicals could not be used because they has a "peptonizing effect upon the color present." Whiting was used successfully during these months to provide alkalinity. Whiting yielded much longer filter runs.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

One Reason for Short Filter Runs. W. J. ELDRIDGE. Water Works Engineering, 81: 20, 1405 and 1429, September 26, 1928. An interesting discussion of the effect on various concentrations of microscopical organisms on the length of filter runs at the Iron Mountain, Michigan, filtration plant. Observations were made in actual practice and conditions further observed in experimental filters with controlled densities of organisms. Several methods were adopted to cope with the problems but no method has been adopted which is effective in cleaning up the water when low concentrations of organisms are present.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Municipal Works at East London, South Africa. A. P. LAING. Surveyor, 74: 1907, 133, August 10, 1928. The present water supply at East London, South Africa, consists of a pumping station at Wilsonia on the Buffalo River which furnishes water to the Umzoniana reservoir with a capacity of 255,000,000 gallons. From the earthen reservoir water passes through a canal

fitted with baffle plates into two settling tanks, each of 1,000,000 gallons capacity, and thence to three slow sand filters, each of 500,000 gallons capacity. In addition there are two concrete service reservoirs for storage of filtered water. Only when river water is very turbid is ferric-alumina used and then only in small quantities.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Report on Water Supply for Ottawa. Anon. Canadian Engineer, 54: 23, 591, June 5, 1928. Report of Commissioner of Works, reinstallation of a filtration plant on Lemieux Island, Ottawa, Ont. Rapid sand filtration is recommended owing to the color of the Ottawa River water. The capacity suggested is 34 m.g.d., with two filters in reserve, the estimated cost being $1,190,000. The cost of operation, on basis of average consumption of 22 m.g.d. would be $62,000 per year. The present cost of chlorination is $16,000 per annum. If filtration is adopted, 100 per cent metering is recommended, the cost being estimated at $425,000. It is believed that complete metering would reduce the per capita consumption from the present value of 160 to 100 gallons per day. Twenty-two per cent of the total water supplied is delivered through meters.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

The Bacteriophage of D'Herelle in Potable Waters. Paul Fabry. Revue d'Hygiene et de Medecine Preventive, 50: 9, 667, September, 1928. Bacteriophage was isolated by seeding 10 ml. of sample in 10 ml. of ordinary broth, followed by filtration after twenty-four hours incubation at 37°C. through a candle filter (L_3). The filtrate was then tested for lytic powers against *B. coli* and the Shiga bacillus. Filterable varieties of pathogenic organisms can pass through filters along with the bacteriophage. The isolation of bacteriophage from a water is an indication of pollution, as the bacteriophage is of intestinal origin. *B. coli* originally present in water may have been destroyed by bacteriophage.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Preliminary Note on the Sterilization of Bilharzia—Infected Water. H. S. Blackmore. Journal Royal Army Medical Corps, 51: 4, 262, October, 1928. "As the result of previous work, it has been generally accepted that the cercariae remain alive for at least an hour in water containing from 4 to 10 p.p.m. of available chlorine, and hence the use of chlorine for this purpose is impractical under field service conditions. We were encouraged to try the effect of a chloramine solution because of its apparently much greater efficiency as a protoplasmic poison." Results of this preliminary work show that: (1) In bilharzia—infected tap water samples containing chloramine solution giving 1 p.p.m. available chlorine, freshly secreted cercariae became immobile in five minutes; (2) contrary to present opinion, the regulation army chlorinating treatment for the destruction of pathogenic bacteria does kill the cercariae. The prescribed treatment of tap and river water with the requisite amount of bleach solution killed cercariae well within the prescribed thirty minutes treatment period for ordinary water purification with the Horrocks apparatus. —*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Storage of Polluted Water on Board Ship for any Purpose not Recommended. Anon. United States Naval Medical Bulletin, 26: 3, 732, July, 1928. A review of the storage of contaminated fresh water on board several naval vessels for use in the boilers with an account of an epidemic on board a ship which was caused by this practice. A description of how contaminated water was used safely on board several naval vessels for boiler purposes is also given. —*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Construction of Water Plants. Jour. Amer. Med. Assoc., 92: 824, March 9, 1927. Letter from correspondent in Turkey, gives provisions of law of April, 1926, requiring all municipalities to make provision for an adequate and clean water supply within five years of date of promulgation of law. Plans must be submitted to ministry, and construction commenced within two months of approval of plans. Privately owned springs may be expropriated. The prime minister, the minister of the interior, and the minister of hygiene are charged with the execution of the laws.—*J. H. O'Neill.*

The Use of Chlorine in Water Purification. Geo. C. Bunker. Jour. Amer. Medical Assoc., 92: 1, 1–6. January 5, 1929. Brief review shows extensive use of chlorination process. Methods and types of treatment described, including treatment of supplies used by travelers and armies. Close relation demonstrated between reduction in typhoid mortality rates and purification of public water supplies. Chlorination by chlorine produced by electrolysis of common salt, is a logical development for supplies in Central and South America, as well as in other countries located at a considerable distance from points of production of liquid chlorine.—*J. H. O'Neill.*

Sub-Surface Water—Its Manner of Formation and Its Forms of Appearance. (Das Untergrundwasser, seine Bildungsweise und seine Erscheinungsformen.) Prof. Dr. F. Röhrer. Gas- und Wasserfach, 8: 174 and 9: 199, February 23 and March 2, 1929. The author introduces his subject in an interesting manner by reciting early theories relating to the production of sub-surface waters: those of the Jesuit, Athanasius Kircher, 1664; of Mariotte, 1711; of de la Metherie, 1797; of Christian Keferstein, 1821; of Dr. Vogler, 1877. He then examines the opposing theories: I the Infiltration, and II the Condensation Theory. In the former he touches upon surface run-off, evaporation, and water penetration into the ground, elaborating upon various factors influencing these procedures. He then draws the conclusion, based on certain figures, that 20 per cent of the rainfall may be accepted as the average amount of water which reaches ground storage; this proposition holds for large areas only. The author believes that while there exists unquestionably some condensation of water below the surface of the earth, its volume cannot be appreciable in proportion to the amount originating from rainfall. Different forms of springs are illustrated, with the actuation of rising types of hydrostatic pressure or by gases.—*Richard F. Wagner.*

NEW BOOKS

Proceedings of the Fourth Annual Conference on Water Purification. Technical Bulletin No. 2, Engineering Experiment Station, West Virginia University, Morgantown, W. Va. 131 pages, November, 1928. **Water Purification Problems in Ohio.** THOMAS R. LATHROP. Water of Mahoning and Ohio Rivers is heavily polluted. Ohio river is frequently in an acid condition; the pH has been as low as 4.8 at Marietta. At Ironton, the *B. coli* per 100 cc. have averaged 19,200 for three years, with a monthly minimum of 6200. Sandusky, on Lake Erie, has had trouble with gas formers which resists chlorination. These bacteria produce gas only after forty-eight hours and only in the chlorinated water; no gas is produced in unchlorinated water. Filter plants on lower Ohio have been bothered with algae. In one day in a plant with four filters the record showed 129 filters washed. One well supply showed an iron content of 70 p.p.m. and pH of 5.8. Sand in filters at Barberton becomes badly coated with manganese from a water supply containing 1 p.p.m. manganese. Manganese has made its appearance in the Ohio river; a recent sample from Steubenville had a manganese content of 4.8 p.p.m. and pH of 4.6. **New Well Water Supply for the City of Mannington.** H. C. COFFMAN. Twelve wells drilled to a depth of about 100 feet form source of supply. Air-lift pumps the water to a receiving well, where it is aërated for iron removal and thereafter chlorinated. **Pollution in the Monongahela River Basin and its Effect on Public Water Supplies.** L. V. CARPENTER. The greatest single waste emptied into the Monongahela river basin is that from the mines. It is estimated that 50,000,000 gallons of acid water per day are emptied into the stream. Analyses of a number of samples showed pH as low as 2.0 and an acidity of 1300 grains per gallon. Water is so acid that steel rails in mines have very short life. Corrugated culverts are completely destroyed in a few weeks. During the period of the test, the bacterial count was low and on a number of days water was sterile. On adjusting the pH of the sterile water to 7.2, bacterial growth developed. The pH of the river varies directly with the stage. Brief summary of treatment. **The Value of Pitometer Waste Surveys.** H. E. BECKWITH. **Progress in Treatment of Paper Mill and Tannery Wastes.** W. W. HODGE. Discussion on coöperative research on stream pollution in Wisconsin. Flow sheets for paper mill wastes treatment plant at East Walpole, Mass., and tannery and wool scouring plant at Norwood, Mass. State of West Virginia in 1926 had 91 industrial plants discharging wastes into the stream. Cherry River paper company has attained a 40 per cent reduction in B.O.D. **Laboratory Control of Filter Plants.** G. S. BUCKHANNON. A general discussion on the standard laboratory tests and their value to the plant operator. **Zeolite Softening Plant at Sewickley, Pa.** D. E. DAVIS. Comparative studies showed the zeolite method to be cheaper than the lime-soda. Average cost per million gallons: lime-soda, \$50.00; zeolite, \$35.80, based on removal of 130 p.p.m. of hardness. Plans and specifications contemplated a choice between upward and downward filtration and between natural zeolite (green sand) and synthetic types. Final choice was green sand with downward filtration. Cost of plant \$158,659. **The Development of Bacteriology.** R. C. SPANGLER. Historical outline of the development of general bacteriology. **The New Water**

Supply System of Parkersburg, W. Va. M. G. MANSFIELD and F. C. FOOTE. Average daily consumption was 2.96 million gallons in 1921, but was reduced to 2.65 million gallons in 1925. The new system consists of 12 drilled wells ranging in depth from 51 to 61 feet. Wells are 38 inches in diameter and are arranged along the river bank. A carbon dioxide removal plant consisting of an aërator slab with spray nozzles, a mixing chamber, clear water reservoir, and pump room was constructed adjacent to the old plant. Provisions have been made for a future installation for iron removal. Free CO_2 is 47 p.p.m.; total solids, 250 p.p.m.; hardness, 167 p.p.m.; iron, from 0.3 to 3.0 p.p.m.; and pH, 7.0. Plant is designed for 6 m.g.d. Wells were constructed by Layne Atlantic Co. **Some Troublesome Weeds Found in Water Supplies.** P. D. STRAUSBAUGH. Cf. this Journal, 20: 6, 888. **The Use of Lime in Water Treatment.** PAUL C. LAUX. Small plant operators usually buy lime locally. A plaster lime containing 50 per cent MgO is only 50 per cent efficient. Dry feed is favored for lime treatment using hydrated lime. Jar tests are outlined for determining chemical dosage. Discussion of proper time to use iron and lime, or alum and lime. Corrosion takes place in 7 steps; the addition of lime following filtration will eliminate corrosion troubles. **Making Chlorine Treatment Dependable and Accurate.** H. S. HUTTON. Most waterworks have more than one pump, but duplicate chlorination equipment in small plants is rare. *Ortho*-tolidine test is an important check on proper chlorination. Operators should not be satisfied with merely furnishing safe water. **Purification Problems of the Williamson Water Works.** PAUL C. LAUX. Water supply is taken from Tug River through intakes located opposite town. River is heavily polluted by mining camps a short distance upstream. Turbidity at the plant is seldom greater than 100 p.p.m. Gas forms in filters and will frequently continue to escape for 20 minutes after filter is out of service. Filter runs when gas is high average about twelve hours. Chlorine application is high, running over 1 p.p.m. Gas formation is due to decomposition of organic matter by bacterial action. Gas forms in 10 cc. portions when water contains 0.4 to 1.0 p.p.m. residual chlorine. Attempts to rectify operation troubles by applying sufficient lime to give causticity to applied water were unsuccessful, because dry-feed apparatus was not large enough for this purpose. Sand grains are black, due to coal dust in water. A crust forms on top of the filters. It is routine practice to rake each filter twice each week. Prechlorination did not relieve gas conditions.—*L. V. Carpenter.*

Colorado River. Surface Water Supply of United States, 1924: Part 9. Colorado River basin. NATHAN C. GROVER, ROBERT FOLLANSBEE, A. B. PURTON, and W. E. DICKINSON. 1928. Water-supply paper 589.—*Arthur P. Miller.*

First Report of the Joint Advisory Committee on River Pollution. Ministry of Health. H. M. S. O., London, 1928. From Bull. Hyg., 4: 26, January, 1929. The Committee investigated the question of the machinery needed to administer river pollution law. A number of prevention acts are cited and the conclusion drawn that there is sufficient administrative authority to enforce the law, although it is brought out that for efficient administration, juris-

dictions should cover an entire river with its tributaries. Under present law, the Ministry of Health may set up a Rivers Board to control the whole length of a river insofar as that river may be subject to the provisions of the Rivers Pollution Prevention Acts. In most cases, it has been possible to effect improvement in rivers under Boards by advice and persuasion, the offenders finding that the knowledge and experience of the Board is helpful to them.—*Arthur P. Miller.*

Sixty-First Annual Report of the Commissioners of Water Works in the City of Erie, Pa., for Year Ending December 31, 1927. 84 pp. The more important improvements carried out during 1927 are outlined briefly and extensive financial data and operating statistics are tabulated. As first step in providing additional intake, need of which is imperative, a tract of land has been purchased west of city limits. Plans are being prepared for this work. Average daily consumption during year was 24,088,683 gallons, equivalent to 193.7 gallons per capita to estimated population supplied of 125,000. Per capita consumption after deducting meter registration was 107.7 gallons per day. There are 30,522 services in use, 1021 or 3.345 per cent being metered. Net addition to surplus was $227,239.18. Construction expenditures totalled $438,155.43. Cost of collecting, purifying and distributing water, including depreciation, was $23.168 per million gallons. Gallons of water pumped averaged 279 per pound of coal consumed. Average amounts of alum and hypochlorite used were 0.145 grains per gallon and 3.1 pounds per million gallons respectively. Wash water averaged 1.82 per cent of water filtered. Of 300 1-cc. samples of raw water examined for *B. coli*, 63 showed positive results, while of 599 10-cc. samples of filtered water examined, none contained the colon bacillus. Value of water supplied for municipal use without cost during year was $53,297.42, exclusive of water supplied free to School District to value of $6,343.56. Usual brief description of works and schedule of rates is included. —*R. E. Thompson.*

Students' Kelvin Bridge. Bulletin 434, 1928. Leeds and Northrup Company. The Students' Kelvin Bridge is a convenient instrument for teaching the Kelvin bridge method for measuring low electrical resistances accurately. In designing this instrument for use in the educational laboratory, special attention has been given to the following features: The instrument is rugged and comparatively inexpensive; range is wide enough to demonstrate applications of method; construction is simple; accuracy; though particularly suitable for instruction, it is adapted to general use in the measurement of resistance from 0.1 to 0.001 ohm when accuracy required is of the order of 0.5 per cent —*A. W. Blohm.*

Automatic Control of Acid Baths. Bulletin 500, 1928. Leeds and Northrup Company. The apparatus described is designed to maintain a uniform strength of acid in a bath used in the mercerizing process. At the same time it furnishes a continuous record of the concentration of the bath, so that the operator may know not only what the acid strength is at a particular instant, but also what it has been at all stages of the process.—*A. W. Blohm.*

Trade Standards. Third Edition, 1928. The Compressed Air Society. This pamphlet embodies the result of extended study and research on the part of executives and engineers associated with the companies that are members of the Society. It embraces the accepted nomenclature and terminology relating to air compressors and their operation, with appropriate definitions. It is published with the belief that there is a need for such an authoritative work of reference and that compressed air engineers and users as well as manufacturers of air compressors will appreciate this effort for the establishment of definite trade standards in the industry.—*A. W. Blohm.*

Standards of The Hydraulic Society. Fifth Edition, 1928. The Hydraulic Society is a trade association comprising the principal manufacturers of displacement and centrifugal pumps in the United States. Pursuant to its aim to be of service to engineers, buyers and users of pumps, as well as to its own members, the Society has collected pertinent technical, engineering and commercial pump data; it recommends standard definitions, terms and practices where such action appears to be feasible; and it has compiled this information in a "Standards" pamphlet for distribution to those interested. An effort has been made to produce a publication that will merit the approbation of the Engineering profession.—*A. W. Blohm.*

The Purification of Water. Burns and McDonnell Engineering Company, Kansas City, Mo. A pamphlet conceived with a view to promoting a better understanding of the nature of problems involved in the purification of domestic water supplies. Illustrations of structures, designed by this firm for the solution of these problems, together with brief description of water purification processes are given. Copies are available for those interested.—*A. W. Blohm.*

Proceedings of Sixth Annual Short School, Texas Association of Sanitarians. Section I, Preliminaries. Section II, Health Education Problems. Section III, Some Important Communicable Disease Problems. Section IV, Food and Drugs. Section V, Water Sanitation. Public Water Supplies. Their Development and Protection. E. C. Sullivan, 90. Some factors to be considered in selection of sources of water supply are the nature and extent of use of contemplated supply; sources available; quantity available; quality available; possibilities of pollution; natural and artificial safeguards which may be employed for protecting supply, and cost of installation and operation of system. **Health Protection Through Certification of Water and Shellfish.** R. E. Tarbett and H. N. Old, 97. **Laboratory Control of Water Supplies.** E. P. Schoch, 104. **Swimming Pool and Tourist Camp Standards.** Dr. A. H. Heath, 105. Writer recommends standards for sanitation of swimming pools as recommended by joint committee on bathing places of American Public Health Association and Conference of State Sanitary Engineers. Swimming pool ordinance of Shreveport, Louisiana, and suggested requirements for tourist camp standards are given. **Section VI, Sewage Disposal. Section VII, Industrial Hygiene.** The Plumbing Code as prepared by the Texas State Department of Health is given in the supplement.—*A. W. Blohm.*

The A B C of Hydrogen Ion Control. Fifth Edition. W. A. TAYLOR, La Motte Chemical Products Company. The fifth edition like the first contains a non-technical and technical discussion of the meaning of pH values, and an enlarged section on "Applications" covering various operations and process control work. The materials and equipment for the analysis of water, sewage and industrial wastes have been grouped separately in the last edition. The new equipment of interest to sanitarians includes the La Motte-Enslow Chlorine comparator and the La Motte Sterilization test set for determining free or residual chlorine; the La Motte B.O.D. set for determining biological oxygen demand; new Nessler tubes with polished tops and bottoms; La Motte Colorimeter for Nessler tube comparison; and La Motte Sludge testing set.—*A. W. Blohm.*

Report of Sanitary Engineering Division. L. F. WARRICK. Quarterly Progress Report, Second Quarter, 35, July, 1928, State Department of Engineering, Wisconsin. Public water supplies in Wisconsin are reported as being in general quite satisfactory on the basis of routine inspections made by the sanitary engineering division of the State Board of Health. A new water filtration plant has been completed and placed in operation at Menasha, Wisconsin. Sewage treatment plant operation studies have demonstrated the need of improvements in design, construction and operation of many plants. Coöperative waste utilization and stream improvement activities of the Wisconsin Pulp and Paper Industry are mentioned.—*A. W. Blohm (Courtesy U. S. P. H. Eng. Abstracts).*

Burst Water Mains. Metropolitan Water Board, London, England. Extract from the Report (No. 2) of the Works and Stores Committee to the Board, February 15, 1929. The recent cases of burst mains which have attracted considerable notice in the public press can be attributed to various causes, but they are not excessive, nor indeed are they above the average number occurring at this time of year. Fractures of mains are caused by a variety of circumstances including (1) changes of temperature; (2) traffic conditions; (3) interference with the support of the Board's mains during road operations or by other works, and (4) deterioration of the iron by the surrounding soil. Cast iron mains are fractured during very cold weather by the admission of water at low temperature from the exposed filter beds to mains lying in the ground at a temperature several degrees higher than that of the water entering the mains. Fractures arising from this source are more frequent in that part of the Board's area where some of the older mains are jointed with iron borings and sal ammoniac, thereby making a practically continuous length of iron pipe and thus failing to provide for the necessary expansion and contraction which pipe joints made with lead afford, as with the present practice. Statistics which were submitted following the severe frosts of 1925 and 1927 confirm the opinion that the number of bursts are fewer in those districts where the water is derived from wells, and therefore nearer the temperature of the mains than that flowing from exposed filter beds. The fractures of the larger water mains which have taken place recently are not to be attributed to changes of temperature, but to other causes. The explosion in Holborn was a disaster over

or for which the Board had no possible control or responsibility. In a recent case there was evidence of the fracture being due to an interference with the original support to the main; whilst another burst may be traced to the weight and vibration of the road traffic. In recent cases of burst mains which were commented upon by reason of the unfortunate dislocation of busy traffic in the City and in the Strand, the mains are not the property of the Board, although in one case the Board's main suffered damage due to water escaping at high pressure from an adjoining hydraulic main. It is notorious that the volume, weight, and speed of road traffic have vastly increased during recent years, and the reconstruction of many of the old roadways in the Board's area in an attempt to cope with this modern need has had a detrimental effect upon mains laid under the streets. In many cases the camber of the carriage-way has been lowered, thereby reducing the depth of the covering above the mains, and where this has occurred and a concrete road-bed brought into contact with the main, damage has undoubtedly been done by direct transmission of weight and by vibration. The Board have in recent years expended many thousands of pounds in laying new mains at a greater depth in streets where the carriage ways have been reconstructed, and in other respects have not failed to take advantage of the opportunities afforded for the reconstruction and relaying of mains and service pipes when street works have been put in hand by the local highway authorities. In fact the Board lose no opportunity of collaborating to the best advantage with the local highway authorities through the Ministry of Transport or otherwise when street works are contemplated or in progress. Whenever bursts or fractures occur constantly on a particular length of main the circumstances are reported to us and the first opportunity is taken to replace the main. It can therefore be observed generally that when frequent bursts occur in a main it is either laid shallow or in soil destructive of the iron. If it is found that the chemical action of the soil has deteriorated the pipes they are taken up and new ones substituted, provision being made for their protection and isolation from the destructive soil by surrounding them with concrete, sand, soil of a suitable character, or chalk. For the most part the Board's mains are of cast iron and the Board have availed themselves of the great improvement made in the founding of cast iron pipes during recent years. As a rule the use of steel pipes has been confined to special cases such as the crossing of bridges, in tunnels, in subways, and where the subsoil has been unduly disturbed and not likely to give the necessary support. When deemed necessary, as when used for conveying water impregnated with iron, a special bituminous lining is spun on the inside of the steel pipes. Any question of a comprehensive inspection or exploration is economically impracticable; but on every suitable occasion—such as the repaving of a roadway by the local authority, or a minor burst upon an existing main—steps are at once taken to ascertain the condition from the point of view of safety of any accessible pipes and apparatus, with a view to immediate renewal or other remedial measure.—*Abel Wolman.*

Report of Bureau of Sanitary Engineering, Maryland State Department of Health, 1928. Abel Wolman. 19 pp. (Mimeographed), 1929. Extensive activities of Bureau during 1928 are outlined. Success of Bureau in combating

typhoid fever is demonstrated by fact that incidence of this disease was by far the lowest in history of the State. Mortality rate was 5.2 per 100,000 for the State, 4.2 for City of Baltimore, and 6.5 for counties of Maryland. This record was attained in spite of occurrence of small epidemics during summer months. Outstanding outbreak was at Eastport, Anne Arundel County, where water supply was obtained from private wells of shallow depth. Epidemic occurred following heavy rains and excessively high tides. Educational work was undertaken by the Bureau and public water system obtaining supply from Annapolis system was installed before end of year. Value of sanitary works for which plans were submitted to Bureau for approval during year was approximately $7,000,000. Brief descriptions of water supply improvements carried out in the various towns and institutions are included. Efforts of Bureau to improve operation of water plants throughout State have met with marked success. Many towns have equipped their plants with testing outfits recommended by Bureau and are submitting detailed weekly reports of daily operation. Work of Bureau in improving conditions of streams of State was continued and substantial progress was made during year. Policy of routine sampling of streams at various points has been established as means of stream pollution control and has proved effective. In continued investigation of paper mill waste of a congoleum company, various coagulants were experimented with. Results with ferric chloride did not justify substitution of this precipitant for alum. Treatment with 90 grains of lime and 50 grains of alum per gallon produced effluent approximately equal to that obtained with 140 to 180 grains per gallon of alum. Supernatant is discharged into stream and sludge to a lagoon, supernatant from latter being passed through cinder and sand beds before being discharged to stream. Treatment of cinder bed effluent with lime would produce excellent floc and a practically water white supernatant, but this is not necessary under the conditions. Experiments were also conducted with various coagulants at a laundry plant. Waste is treated in plant consisting of agitation and subsidence tank, secondary subsidence tank, cinder and gravel oxidizing bed, and sand filter. Most satisfactory results were obtained with 7.2 grains per gallon of chlorinated copperas and 15 grains per gallon of sulfuric acid, effluent being clear and slightly greenish in color. Waste treatment plant at garbage reduction works has improved conditions of stream about plant and resulted in considerable recovery of grease. Of 28 replies to questionnaire sent to steel rolling mills by one steel company, one mill stated that acid in waste was reclaimed by Marsh-Cochran process, one employed spent pickle liquor in manufacture of copperas and 26 did not reclaim acid. Waste treatment methods reported included neutralization with lime and marl and filtration through sand and gravel, while at 16 plants no effort was made to reduce stream pollution by neutralization of acid. Complaints were received during summer regarding color and floating material in Back River in vicinity of Baltimore City sewage treatment plant. Investigations conducted indicated that unusually prolific growths of algae were probable source of trouble. Field investigations disclosed that water was supersaturated with dissolved oxygen, saturation ranging from 112 to 217 per cent. Extensive mats of green algae covered practically entire surface of stream and fish mortality was very great during latter part of summer. Primary causes

were probably very high air temperature and unusually excessive solar radiations. Similar conditions have been noted elsewhere, particularly in streams receiving highly nitrified effluents of sewage plants. Study of canning wastes was also continued. Wastes are passed through 2 screens into receiving vat and, when latter is full, treated with 6 grains of lime and 4 grains of iron sulfate per gallon and pumped to settling tank. This procedure is followed throughout day and tank is allowed to remain quiescent until following morning when clear liquid is run on to large field. Sludge is either discharged on to cinder drying bed or carried away in tank wagon provided for purpose. Complaints were received in November regarding peculiar tastes in Elkton water supply, portion of which is drawn from Elkton River, treatment consisting of rapid sand filtration and chlorination. Plant is employed only when springs located under clear water reservoir are unable to meet demand. Trouble was traced to phenol-containing substances employed in dyeing plant discharging wastes into river. These substances were added to distilled water in proportion in which they might occur in stream water and the mixture chlorinated. No appreciable taste was noticeable until 0.3 p.p.m. of chlorine had been added, when a decidedly disagreeable taste developed. Several studies of waters reported to be corrosive were conducted. One supply contained 20 p.p.m. of free carbon dioxide, pH being 4.2. Aëration and lime treatment were recommended for these supplies. Substitution of sodium aluminate and alum for alum at one institutional plant did not entirely correct red water troubles. Soda ash treatment was effective. Investigation was carried out to determine best method of cleaning brass well screens coated with iron oxide. Hydrochloric and nitric acids removed deposit but attacked the metal. Steam at pressure of 140 pounds per square inch readily removed deposit and was not objectionable from standpoint of dust, which rendered use of air most inconvenient. Method consists merely in discharging steam through ½-inch jet against outside wall of screen and then washing with water. Single screen section can be cleaned in five minutes and cost is negligible. Details also included of investigations relative to oyster pollution, sewage disposal, and aërial pollution. Tabulations showing typhoid mortality statistics and activities of Bureau during year are appended.—*R. E. Thompson.*

Notice!

All correspondence relating to the publication of papers **should be addressed to the Editor, Abel Wolman, 2411 North Charles Street, Baltimore, Maryland.**

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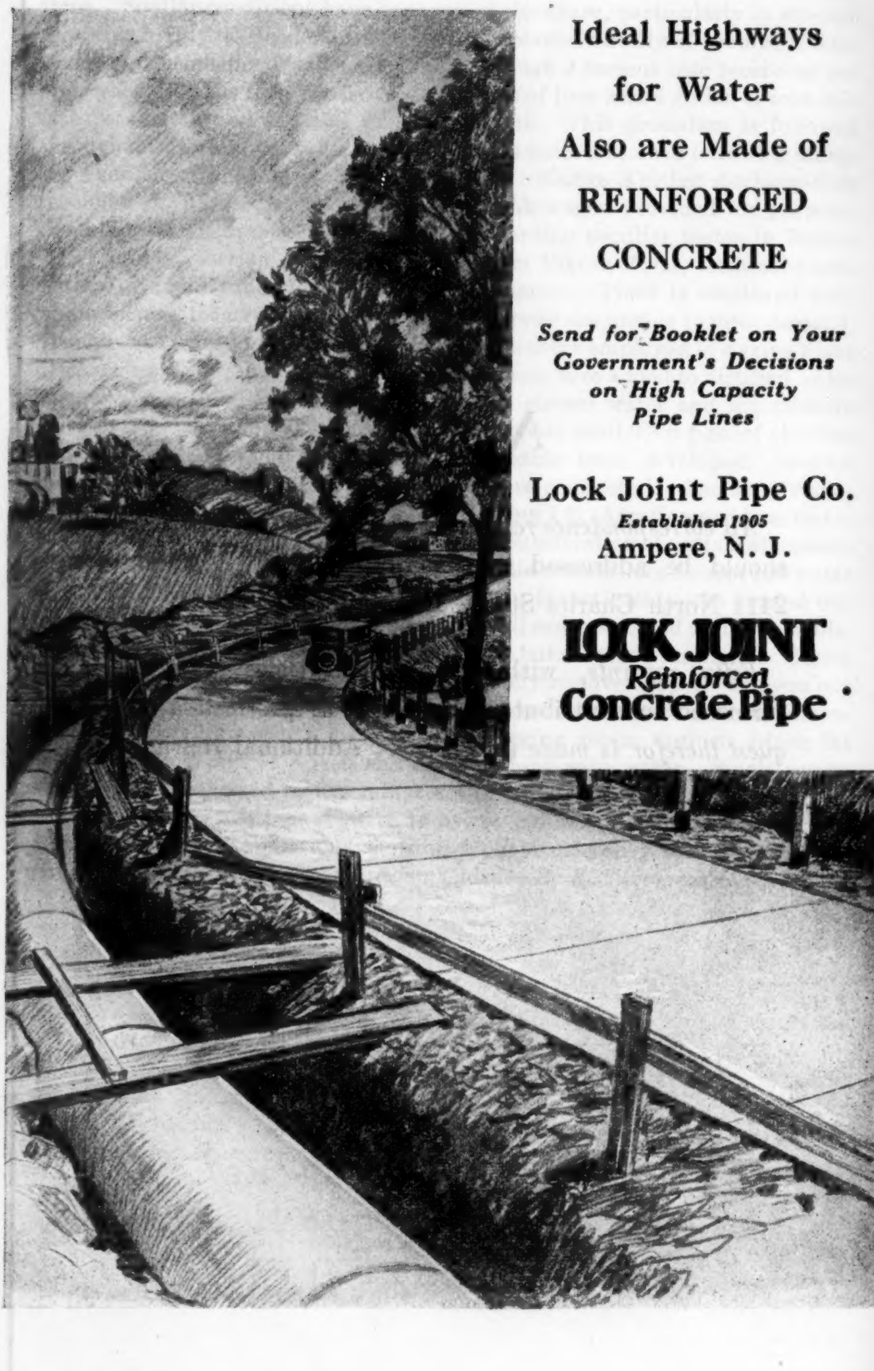
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Section 4. A Corporate Member shall be a water board, water commission, water department, water company or corporation; national state or district board of health or other body, corporation or organization interested or engaged in public water supply work, and shall be entitled to one representative whose name shall appear on the roll of members and may be changed at the convenience or pleasure of the represented Corporate Member upon written request to the Secretary, and who shall have all of the rights and privileges of an Active Member. (Initiation Fee, $10.00; Annual Dues, $15.00.)

Section 5. An Associate Member shall be either a person, firm or corporation, engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works. An Associate Membership shall entitle the holder to be represented by one person on the floor at each meeting but such representative shall not be entitled to vote nor take part in any discussion unless permission is given by unanimous consent of the members present. (Initiation Fee, $10.00; Annual Dues, $25.00.)

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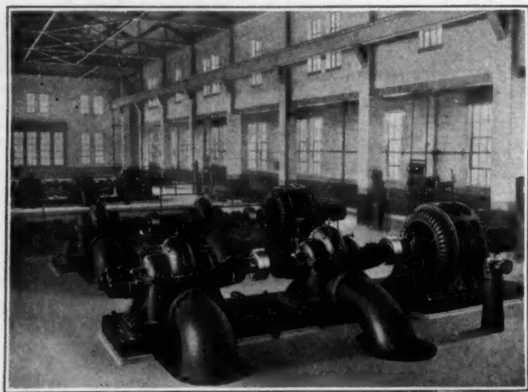

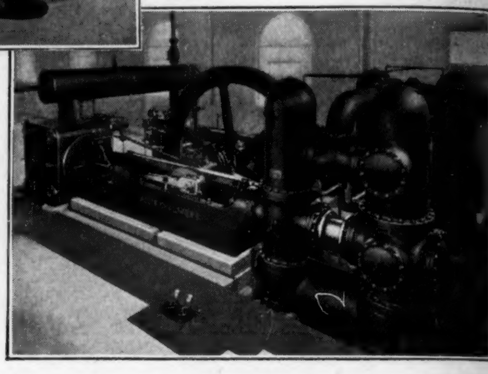

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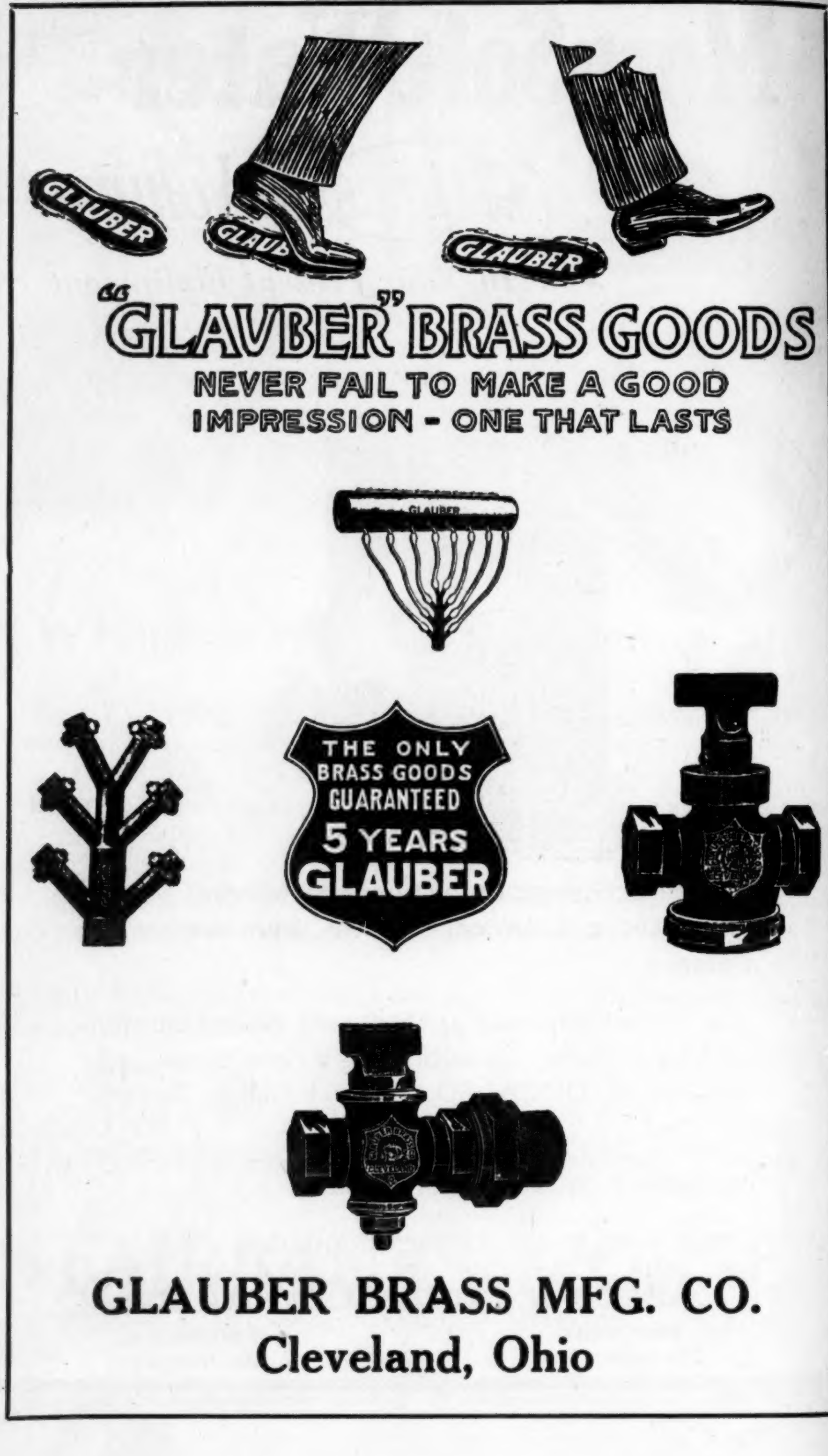
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